UNIV. OF
TORONTO
LIBRARY

P
Agric
I
Imperial Agricultural Research Institute, Delhi
LIBRARY
SEP 14 1910
UNIVERSITY OF TORONTO

MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

ENTOMOLOGICAL SERIES

Volume I

AGRICULTURAL RESEARCH INSTITUTE, PUSA

119627
21/11/11

PUBLISHED FOR
THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY
THACKER, SPINK & CO., CALCUTTA
W. THACKER & CO., 2, CREED LANE, LONDON

11

CALCUTTA :

PRINTED BY THACKER, SPINK AND CO.

CONTENTS.

Vol. I.

		Page.
No. I.	Maxwell-Lefroy, H. The Bombay Locust. (*Acridium succintum*, Linn.) A Report on the Investigations of 1903-04. (With thirteen plates)	1
No. II.	Maxwell-Lefroy, H. The More Important Insects Injurious to Indian Agriculture. (With eighty text figs.)	113
No. III.	Maxwell-Lefroy, H., and Ghosh, C. C. The Indian Surface Caterpillars of the Genus Agrotis. (With one plate)	253
No. IV.	Mann, Harold H. Individual and Seasonal Variations in Helopeltis Theivora, Waterhouse, with description of a new species of Helopeltis. (With one plate) ...	275
No. V.	Green, E. E., and Mann, Harold H. The Coccidæ attacking the Tea Plant in India and Ceylon. (With four plates)	337
No. VI.	Maxwell-Lefroy, H., and Ghosh, C. C. The Mustard Saw-fly. (With one coloured plate)	357

A REPORT OF THE INVESTIGATIONS

ON

THE BOMBAY LOCUST.

By H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Entomologist to the Government of India.

PART I.

THE FORMATION AND MOVEMENTS OF LOCUST SWARMS.

First Period.—Emergence.

During September, 1903, young locusts were reported from the Panch Mahals District of the Bombay Presidency, and were found to be in the last stage prior to maturity. In October the winged locusts were found in Panch Mahals, Surat, parts of Khandeish, Baroda, Ahmedabad and Thana, in scattered localities from Bombay to Ahmedabad, mostly within 100 miles of the coast. The crop reports mention the presence of locusts in the Panch Mahals early in September, and in Ahmedabad in the third week of the same month. The reports from Baroda mention locusts from the 5th September onwards. Apparently large numbers of young locusts were to be found in Gujarat and the North Konkan during September, had search been made for them. In the Surat district, full-grown locusts were found in the long grass grown for hay. They remained concealed in this grass until they emerged during the middle of the month, when

the grass dried and was cut. During the latter half of the month, these locusts entered the crops and found ample shelter in the fields of juari, (*Andropogon sorghum*), where they fed on the leaves and ripening grain. This happened also in Broach, Panch Mahals and Kaira, as well as in the Baroda State. Immense numbers of locusts appeared, wandered aimlessly about for a time, gradually formed into swarms and moved over the country side. In the Surat District the swarms were closely watched; they moved little at first, the swarms not being compact, and did much damage to crops in some villages where they stayed for a long period. Gradually the swarms formed, moved from field to field, and finally became definite bodies of locusts whose progress from village to village could be clearly traced. The approximate area from which the locusts emerged is marked in the Map, Plate II.

Second Period.—Migration.

Late in October the swarms commenced moving in a definite direction. The migration was on the whole from north to south with a trend inland from the coast. The numerous reports from district officers, the very full evidence of the officials in Baroda State, the information furnished by the Diwan of Rajpipla State, all agree in defining a regular migration, observed by day in the movements of the swarms, or observed in the places in which swarms successively alighted in their passage through a district. The movement commenced earlier in the Northern districts, but as a whole the main movement was in progress early in November. They passed through Kaira, Baroda, Rajpipla, Broach, Surat, into Ratnagiri and Kolaba and the adjoining hilly forest regions. This continued throughout November and by the end of that month only scattered swarms remained which disappeared during December. The locusts in Eastern Khandeish appear to have pursued a similar course, their migration being south westwards into the Ghât region, over the Nasik District. Probably there were other unreported swarms which moved at this time, all apparently centering on the hilly forest Ghât region. This period

closes in December with the arrival of the swarms in the Ghât region.

The origin of these swarms admits of little doubt when the whole evidence is considered. They were hatched in the localities where they were first seen, spending the hopper stages there and only appearing when full grown, except in parts of Ahmedabad and the Panch Mahals. This statement is based on observation, and is the only inference possible from the reported facts and from investigations into the life history. The large area of grass land especially near the coast of Gujarat was probably full of small and harmless hoppers in the rains of 1903, unnoticed because they were concealed in the long grass. With the ripening of the grass, the hoppers became winged, spent their first few days there, emerged into the crops in search of food and finally packed in swarms for the migration to the Ghât region. This is fully borne out by observation of the young locusts in the rains of 1904.

It must be remembered that locusts are not invariably seen or reported, nor is there any record of their occurrence in ordinary years. The distribution of the locusts and their origin in 1903 are thus only partially known ; many localities are probably permanent breeding places, *e.g.*, places in Portuguese territory (Goa), the forests of Kanara and other parts of the Western Ghâts, without such a fact being now ascertainable. B. P. Standen, Esq., Director of Agriculture, Central Provinces, states that the locusts have been permanently in Nimar and Holkar's territory for four years ; there are doubtless other such places. A safe statement would appear to be that the main mass of locusts in 1903 was bred in Gujarat, with a contingent from Khandeish and from permanent breeding places in the Ghâts and hilly forest tracts in Western India.

The migration during November took place chiefly at night, which accounts for the somewhat mysterious manner in which locusts appeared and disappeared. Many swarms were traced for days on end and then vanished in a single night, the watchmen stating that they flew away during the night. For many nights immense numbers of locusts were seen passing

over Surat, not in swarms but singly. The air seemed to be full of locusts, whose wings glistened as they flew across the moon and then vanished. An endless stream was to be seen on moonlight nights and the movement probably continued on dark nights also. Migration for any distance during the day was rare but did occur. As a rule the limit of the day flights was a few miles. Apparently these prolonged nocturnal flights carried the locusts over long distances, bringing them eventually to their destination in the forests. There is nothing unusual in such flights, which are a feature of locust swarms.

The true migratory locust, *Acridium peregrinum*, also appeared in Gujarat after the swarms of Bombay locusts, *Acridium succintum*, had left. Kathiawar reported swarms of this true migratory locust in November, and swarms were seen alighting at places along the coast, apparently after their flight over the Gulf of Cambay. These swarms passed through the Surat District in early December, compact swarms flying by day and visible far out to sea as they approached land. The fate of these swarms is still unknown; no specimens of *Acridium peregrinum* were caught among the swarms of the Bombay locusts.

Third Period. The Winter Months.

The end of November and early December found the swarms settling in the forest regions on the Ghâts, including parts of the Kolaba, Ratnagiri, Khandeish, Nasik, Poona and Satara collectorates. These had come through Thana principally, the first swarms late in October when they settled so thickly on the trees of Bassein as to break down their branches. During late November and December they spread over the forests, an area of some three hundred miles long and forty broad. From December to March they remained in this area, feeding upon the forest trees, moving in vast swarms during the day. From Kalyan southwards through Pen, Mahableshwar, Satara, Chiplun, Kolhapur and the Northern part of the Belgaum district, locusts occurred in vast swarms and were to be seen in countless numbers along the G. I. P. and Southern Mahratta railways that run to Poona. This area is shown in Plate II.

Fourth Period.—Second Migration.

During the second half of March and the beginning of April, the outward movement from the Ghât region commenced. The movement was from the Ghât region to the interior, that is, to the North-East, East and South-East mainly. The movement to the North-East was a very large one, the swarms passing over Thana, Nasik, Poona, Khandeish and Ahmednagar: others moved eastwards over Sholapur and Bijapur, and a large movement took place over Belgaum and Hyderabad, Dharwar and Kanara. The swarms proceeding North-East penetrated to the Panch Mahals and Rajpipla, to Bhopawar in Central India, and over the Western half of the Central Provinces as far as Nagpur. They arrived in Panch Mahals in May, in Rajpipla in May and in Chota Udaipur in June. The swarms going East and South passed into Hyderabad, into Bellary, Kurnool and Anantapur, and moved through Belgaum into Dharwar and Kanara. Many swarms came back to the Ghât region after they had moved out into the hot dry Deccan, leaving Bijapur, Sholapur, Belgaum and Ahmednagar clear; these settled in the Ghâts and remained there. At the close of this period, the locusts were within the Ghâts, and spread over an area embracing part of Gujarat, the Western part of Central India and of the Central Provinces, Berar, part of Hyderabad and of Madras; large districts in this area were free from swarms, the locusts only occupying part of the enormous area invaded. On the 24th June, 1904, the Director of Agriculture, Bombay, states (G. R. 5587) that Ahmednagar, Sholapur, Bijapur, Dharwar, Belgaum, Kanara and Kolhapur were practically free from locusts.

The available information as to the whereabouts and movements of locusts is inadequate to detail accurately their history; many places were probably infested with locusts which bred there year after year, and the matter is not known or reported as it excites no interest.

Fifth Period.—Scattering.

After this outward movement, the locust swarms broke up shortly before the end of May. Swarms were no longer to be

seen, and the infested areas contained enormous quantities of active locusts spread and scattered singly. A vast area of country was infested (Plate II.), but little or no damage was done and the locusts had apparently lost the swarming and migrating instinct. This may have been due to lack of food for such vast swarms at that season or to the instinct which leads them to scatter before the period of reproduction. Food was scarce, and scattered individuals spread over a large area would evidently find food where a moving swarm would not do so. In fact, the insect now ceased to be a locust and became a grasshopper, not more numerous than other grasshoppers and no more destructive had there been crops to destroy.

Sixth Period.—Reproduction.

Early in June the rains fell in parts of Western India, and the locusts entered upon the last period. Coupling and egg-laying took place during June and July, depending upon the date on which heavy rain fell. The locusts remained scattered, not swarming or moving, and simply reproduced where they were and died.

By August, and even earlier in some places, practically all the locusts were dead. For a whole year they had lived, spending at least ten months of that time *in the winged condition.*

The periods noted above were roughly as follows :—

Winged locusts emerged and entered crops.	October 1-20.
,, ,, migrated.	Oct. 20—Nov. 30.
,, ,, remained in forests.	Dec. 1—March 20.
,, ,, migrated.	Mar. 20—May. 20
,, ,, scattered.	May 20—June 10.
,, ,, reproduced and died.	June 10—Aug. 10.

These dates are approximately accurate for the whole mass, although small variations occurred in many places. They represent the average periods for the whole area involved.

PART II.

LIFE HISTORY.

Development of the Reproductive System.

On first appearing in September and October 1903, the locusts were examined to see whether the reproductive system was developed. It was of extreme importance to know when the eggs would be laid and on the analogy of the North-West locusts this was expected at once. The reproductive organs were then found to be very small, consisting of the narrow white ovary or testis in a completely undeveloped condition, with delicate oviducts or vasa deferentia leading to the external genital opening. The body was practically destitute of fat body and the abdomen was largely filled with the air sacs attached to the main longitudinal tracheal trunks. The nervous system, the alimentary canal, the tracheal system present no structures calling for special notice. From time to time, the reproductive system of freshly caught locusts was investigated ; no signs of development were noticed until the following April when it was found that the reproductive organs had increased slightly in size, and were encased in a small mass of yellow fat body.

During May, the reproductive system increased in size ; the egg tubes were distinctly visible, the oviducts growing larger with thickened walls ; the testes and vesiculæ seminales also increased in size and in both sexes a larger amount of fat body was formed. At the same time the locusts became increasingly sluggish ; by the end of the last migration outwards from the forests the reproductive system commenced to occupy a large part of the abdomen and with its increasing growth the flight of the locust became more and more unwieldly and slow.

During the end of May and first week of June the reproductive system became fully developed; by the 10th of June many specimens had mature reproductive organs and copulation took place. In some places this was delayed until July, and even with locusts caught in any one place there was great variation in the degree of maturity of the ova and testes.

The mature female reproductive system consists of two large ovaries, each formed of about fifty short egg tubes opening into the expanded oviduct, which unite from each side in a single duct passing to the external genital opening: a very small sebific gland opens by a duct above the external genital orifice. (Plate III., fig. 1.) The oviduct of each side becomes a solid twisted cord at the anterior end of the ovary and passes into the anterior portion of the abdomen. The egg tubes form a large yellow mass, cased in a fat body and enclosed in a single membrane embracing both ovaries. The number of egg tubes on each side is 50 to 60, the delicate ends of the tubes turned inwards; the oviducts are laterally placed and somewhat swollen, of a bright orange colour. The posterior end of the body consists of two paired chitinous processes, one dorsal, one ventral, closely pressed together; the anal opening covered by the pygidium is dorsal, the genital opening concealed by the sternum of the last segment is ventral. (Plate III., figs. 2, 3, 4.)

The male reproductive system consists of two large testes, enclosed in a common envelope, with masses of yellow fat body surrounding them. (Plate III., figs. 8 and 9.) Each testis consists of numerous short fine tubes, opening into the vasa deferentia; the two ducts unite and open at the hind end of the body; the accessory glands and vesiculæ seminales have the form of long twisted tubes forming a convoluted mass at the extremity of the abdomen, and open into the vasa deferentia close to the external opening.

The vasa deferentia lead to the penis, a muscular and chitinous organ opening on the dorsal side of the large ventral process; the penis is retractile and in copulation projects upwards from the ventral process. The spermatozoa are long

needle shaped bodies with minute heads ; they lie in bundles in the vesiculæ seminales at the time of copulation.

Coupling.

With the first rains in June, the reproductive system matured, and coupling commenced within a few days of the rain falling in appreciable quantity and continued during about two weeks.

The male grasps the female with his forelegs on her prothorax, the middle legs on the junction of abdomen and thorax, the hind legs being drawn up ; the body is over the body of the female, the abdomen curling round to one side, so that the penis can be extruded in an upward direction and enter the genital opening of the female. The conspicuous shield of the male genital opening extends in a posterior direction, looking downwards, and the female retracts her abdomen telescopically to admit of the entrance of the penis. The operation is characteristic and cannot be mistaken. The male stridulates, raising the hind leg, running the teeth along the wing, producing a low sharp chirp ; at no other time is stridulation observed.

Coupling lasts many hours and is not complete under fifteen to twenty hours ; a pair coupling in the evening will remain so till the next day. Coupling goes on from day to day, promiscuously ; one may see quite one-third of the locusts coupling daily for at least five days on end and the operation would appear to require more than one day for completion. Many females couple when the ova are immature, others apparently in the interval between impregnation and egg-laying.

Couples separate if disturbed, after making unwieldly jumps along the ground. Coupling locusts may be found on the bushes in wet weather, on the ground in fine. After coupling the male locusts die ; the females remain active, waiting about five days before laying eggs. The transfer of these spermatozoa to the oviduct of the female is a lengthy process. There appears to be no distinct expulsory effort on the part of the male, nor does the structure of the vesiculæ seminales show that such efforts are possible. An examination of the organs

and close observation of coupling locusts suggest that, union being established, the spermatozoa move from the vesiculæ seminales, through the penis, up the oviducts, by their own efforts. It is probable that there is some chemotactic attraction in the ovary, drawing the spermatozoa from the vesiculæ seminales to the ova: the mucilaginous matter of the accessory glands appears to fill the penis and provide a medium for the passage of the spermatozoa into the oviduct, which is also filled with mucilaginous matter.

Egg Laying.

The deposition of eggs in the ground has been observed in the field and in cages. A female about to lay eggs walks about feeling the soil with the palps, apparently testing its consistency with the jaws. Having found a suitable place, she raises herself on her legs and curls the abdomen over, till the tip rests on the soil. The hooks are then pressed in and the two pairs of powerful digging processes press the earth apart, to the front and rear of the vertical end of the abdomen. This digging continues in a nearly vertical direction, the abdomen steadily descending and the locust moving backwards to get pressure on the hooks. The abdomen is forced in till the hole is about two inches in depth, when the locust is standing nearly over the hole, the abdomen buried up to the basal segment. If the digging has been satisfactory, eggs are laid, the eggs pouring out between the processes, gradually filling up the hole. (Plate IV., fig. 1.) When all the eggs, numbering 100 to 120, are laid, a mass of gum is poured in which covers the eggs and sets as a smooth surface, a little way below the level of the soil. This gum is a frothy white matter, turning slightly buff in colour, which binds the eggs together and covers them over. It is at first soft and frothy, but sets hard in a few hours and the whole egg mass can then be removed intact. The upper part of an egg mass consists of pure gum, containing no eggs. This process takes from one to two hours from the time the locust commences to dig into the ground. A considerable time is required to make a satisfactory hole, after which the

eggs are laid in half an hour. In the field locusts make many ineffectual attempts to lay eggs, digging holes to a certain depth and then finding stones or water or some unsuitable condition. Many of these holes can be found in the field. Frequently the hole is not vertical but curved; it is rarely straight, usually slightly curved, often very much bent, in order to pass some obstructing stone. In soft earth in captivity the eggs may be laid deeper and the white mass of gum is not visible from above.

It is not easy to recognise a laying female except by the fact that she does not move on being approached. On coming close, the abdomen can be seen passing into the soil. Should the hole not be complete, the female will often leap away if disturbed. If eggs are being laid, she moves only with great reluctance and can be carefully observed during the process.

The Egg Mass.

The whole egg mass is from 1 to 2 inches long, nearly cylindrical, straight or curved according to the nature of the ground and the hole. (Plate IV., fig. 2.) When the soil is gravelly, the holes and the egg masses are twisted or curved; in fine soil the egg mass is straight. The yellow eggs can be seen in the gum. Each egg is like a yellow rice grain, cylindrical, about $\frac{1}{5}$ inch long. The egg mass contains about 110 to 120 eggs.

After the gum hardens, the whole egg mass is easily moved intact with a little care. During the course of the development of the eggs, the frothy gum no longer binds the eggs together: this is due partly to the swelling of the developing eggs, partly to the gradual drying of the gum or to other changes in it. The majority of eggs found during the second half of development are loose and not in a compact mass. The eggs change colour during development; the outer skin of the egg is at first transparent and allows the orange colour of the egg to be seen. Later it becomes opaque, a dirty brown colour, getting a tinge of green as the egg becomes mature. Soon after the eggs are laid the female locusts die They lay eggs once only,

in a single mass. In cages they die the same day ; in the field they were found dead in large numbers when the egg-laying was at its height. They apparently do not live long after egg-laying, for it is rare to find living females that have laid eggs.

The periods occupied in coupling, egg-laying and dying were carefully observed in several places, and these agree fairly well. The dates at Shahpur, Thana district, were :—

Rain.	11th June.
First coupling.	15th ,,
First eggs.	20th ,,
Main coupling.	20th to 30th June.
,, eggs.	25th June to 5th July.
Diminishing coupling.	1st July to 8th ,,
,, eggs.	5th ,, to 15th ,,
Locusts died.	24th June to 18th ,,

Similar periods were observed in Igatpuri and Kasara, and these agree with the reports and observations from other places. It may be noted that these apply only to places where sufficient rain fell during the whole period to admit of egg-laying going on continuously.

Eggs Hatching.

After the lapse of the incubation period, the whole egg mass hatches, all the little insects emerging often within a few minutes. The outer eggshell breaks in various ways, the end over the head often coming off as a cap on the head of the young locust, or the shell splitting along its length where the legs press against it. No special device appears to exist for opening the egg ; the young locust apparently presses with its hind legs, either forcing off the end with its head or splitting the egg shell where the spiny tibia presses against it. The young locust may shed the delicate inner skin (Oolemn) inside or come out clothed in it, when it is at once shed. The period within which the eggs hatch varies in different circumstances. The details are discussed in a later section and the actual periods of all eggs hatched in captivity are there given. As a whole, the eggs in the lower lying localities, such as Thana district, hatched in about six weeks ; those at the top of the

Ghâts, where the temperature is lower, hatched in from seven to eight weeks. The conditions at the edge of the Ghâts are peculiar, the heavy rainfall and high winds producing a lower temperature. For most parts of Western India the average period is apparently about six weeks. This agrees generally with observations in the field, where no precise periods can be ascertained owing to the long period over which egg-laying is spread.

Development.

On hatching the young locusts are at once active and commence to feed. The insect is now very small, with fully developed limbs and internal organs, with the sole exception of the wings and genital organs. If food is abundant and the conditions suitable, there will ensue a steady growth in size, entailing frequent moults of the outer hard skin, a development of the internal genital organs and a development of the wings. As the insect feeds, more tissue is formed within its body and at regular intervals the whole skin is cast ; the insect then has an elastic soft skin that expands and gives room for a further growth. It is soft only for a few hours and then hardens. When this expansion is utilised another moult takes place. After the third moult the wings appear as tiny lobes, which grow larger at every subsequent moult. At the last moult, the outer skin is fully developed, the insect has attained its full size and can fly. It is still not mature, the full development of the genital organs being deferred until the lapse of many months. The process of development then is a steady process marked by no violent changes. Colour changes occur with every moult and, subsequently, colour changes take place without moults. From the time the egg hatches till the locust dies eleven months later, the development is marked only by (1) the full growth of the wings, allowing of flight and migration, (2) colour changes, of which three are conspicuously marked, (3) the final sudden development of the genital organs after the last migration. The moults in the first period occur with fair regularity. At each moult there is a small change in

colour and a growth in size. In captivity there was a variable number of moults. The following table gives the periods from egg to full grown insect :—

No.	Date of Hatching.	1st Moult.	2nd. Moult.	3rd. Moult.	4th. Moult.	5th. Moult.	6th. Moult.	7th. Moult.	8th. Moult.	Total number of days.
32.	26. VII.	6. VIII.	17. VIII.	9. IX.	9. IX.	16. IX.	26. IX.	5. X.		71.
34.	26. ,,	6. ,,	22. ,,	29. VIII.	7. ,,	11. ,,	19. ,,	27. IX.		63.
39.	26. ,,	6. ,,	18. ,,	29. ,,	5. ,,	16. ,,	28. ,,			64.
13.	28. ,,	6. ,,	16. ,,	25. ,,	4. ,,	11. ,,	19. ,,	27. ,,		61.
14.	28. ,,	5. ,,	12. ,,	20. ,,	29. VIII.	7. ,,	15. ,,	4. X.		68.
46.	28. ,,	6. ,,	15. ,,	24. ,,	1. IX.	8. ,,	17. ,,	5. ,,		69.
49.	28. ,,	5. ,,	15. ,,	24. ,,	2. ,,	10. ,,	20. ,,	6. IX.		70.
50.	28. ,,	5. ,,	12. ,,	19. ,,	27. VIII.	5. ,,	13. ,,	28. ,,		62.
55.	28. ,,	5. ,,	13. ,,	21. ,,	29. ,,	5. ,,	13. ,,	30. ,,		64.
56.	28. ,,	5. ,,	14. ,,	23. ,,	31. ,,	8. ,,	18. ,,	2. X.		66.
60.	25. ,,	1. ,,	9. ,,	17. ,,	26. ,,	2. ,,	9. ,,	19, IX.	3. X.	70.

At the last moult the insect appears in its final shape with fully-developed external genital organs, and it is then able to fly. The two notable points in its history are, first, the colour changes, and, next, the development of the mature reproductive system.

Description of Hoppers after each Moult.

First Stage. (Plate IV., fig. 3.)

Length from head to tail, 7 m.m. (5m.m.).

,, ,, ,, to end of legs. 11 m.m.

General colour green. Eyes dark.

Head grass green, with short yellow-green antennæ ; thorax and abdomen yellow.

Legs and lower part of thorax green.

Legs, antennæ and body speckled with tiny black spots visible only under a glass.

Hind legs with tiny black tipped spines, and short white hairs visible under a glass.

Second Stage. (Plate IV., fig. 4.)

Length from head to tail, 11 mm. (8 mm.).

General colour, green. Eyes dark.

Head green; antennæ slightly brown; thorax, abdomen, and legs green.

The black speckles are abundant on the head, legs and upper part of the body; a dark line on each side of the mid-dorsal line runs along thorax and abdomen, with a light line between.

Third Stage. (Plate IV., fig. 5.)

Length, 13 mm. (12 mm.).

General colour green. Eyes dark.

Head green; antennæ dark brown; 16 joints.

Thorax, abdomen and legs green. Black speckles abundant on the head, legs and upper part of the body.

A mid-dorsal longitudinal white line, with a broader dark line on each side. Mandibles brown tipped.

Pronotum prominent. Meso and Metanotum distinct, the posterior angle slightly produced. Eyes green, with a dark stripe in front.

Fourth Stage. (Plate IV., fig. 6.)

Length, 15 mm.

General colour green, black striped.

Head green; antennæ black; 21 joints, white ringed.

Thorax, abdomen, head, legs, green black speckled.

A dark streak under each eye. Eyes banded in chestnut. Prothorax large, black speckled.

Meso and Meta-thorax small; rudiments of wings green, larger. Abdomen green, much speckled with black.

Fifth Stage. (Plate IV., fig. 7.)

Length, 23 mm.

General colour green with slightly yellowish tinge above: median dorsal longitudinal black stripe distinct; dark speckled all over.

Head green; antennæ black with the white rings fainter; number of joints 22.

Eyes dark brown with a distinct vertical dark streak under each; the streak is white-edged anteriorly and posteriorly.

Prothorax large, green, black speckled with a whitish median longitudinal rudiment of a crest or carina.

Meso-and Meta-thorax green with anterior portion of the dark streak; rudiments of both the wings visible.

Abdomen green, with a distinct black stripe above. The latter is bordered on the right and left by a narrow patch of white colour. A white line on each lateral side; ventral side pea green.

Limbs, green, black speckled especially the hind femora; near the knee joint of the latter there are two (one faint) patches of dark colour which appear like transverse rings.

Sixth Stage. (Plate V., fig. 1.)

Length, 30 m.m.

General colour light green, with the dorsal black line distinct. Body black speckled all over.

Head light green, two rows of dark tubercles extending from the epicranium to the labrum. Eyes with the dark vertical line under each with the white edge well marked.

Clypeus and labrum slightly brownish in colour. Antennæ black, white ringed, joints 23.

Pronotum, large, green, with the dark speckles turned a little brown. A row of dark spots on the hinder edge, 8 or 9 on each side of the median line. The rudiment of whitish crest stated in the last stage has become distinct.

Meso- and meta-notum completely covered above by the rudiments which are 5 m.m. long. The wing nervures are distinctly seen. Two black spots on each wing.

Abdomen, yellowish green, the black patch above with its yellow borders distinct. It extends from behind the wings to the last segments. Black speckled all over. Ventral surface green.

Limbs, green, dark speckled especially the hind legs. The femoral and tibial regions of the latter are brownish in colour. The spines on the tibiæ distinct.

Seventh Stage. (Plate V., fig. 2).

General colour light green, with a brownish tinge all over, dark speckled.

Limbs reddish brown.

Head brownish green, eyes brown, the two rows of tubercles in the clypeal region appear as a pair of parallel ridges dark brown in colour.

Pronotum brownish green; the speckles dark brown instead of black.

The median whitish crest distinct; a whitish rim on all sides of the shield.

Meso-and Meta-notum hidden by wings: wings extend 14 mm. from the pronotum.

The upper edges of the wings touching the median dorsal side of the body are dark. Two dark spots on each wing cover.

Abdomen light green with minute dark spots, and the black dorsal stripe.

Limbs brownish green; the hind limbs have the femoral and the tibial regions brown; the spines appear whitish; a dark streak on the hind femora.

Colour Changes.

These fall into three chief colour schemes, the first or "dry grass colour," the second or "swarming colour," and the third or "wet ground colour."

When the locust becomes winged, it is of a general brown colour, with conspicuous yellowish stripes on the neck and wings. This colour is similar to that found in many grasshoppers which live in dry grass, a colour in which the brown background and lighter stripes assimilate them to the light and shade observed in ripe dry grass. It is conspicuous on green grass or green plants, and very noticeable when in flight. During the first migrating period, the body and head become suffused with brilliant red, bringing a resemblance to the "migratory locust," when it is purple red in colour. This colour is of various degrees of intensity and, though assumed by nearly all, is not absolutely universal. This colour persists through the first migrating

period, the cold weather period when the locust moves in swarms, and the second migrating period. It lasts in fact over the whole period in which the locust forms swarms. One may conjecture that the red colour facilitates swarming ; the main body of a swarm settling on the trees at dusk is brilliant red, easily seen for miles, which may be an important factor in preserving the swarms intact or in gathering the locusts into swarms. In some districts of the Deccan, this colour gave place to a bleached whitish appearance, a faded replica of the first colouring, but this was uncommon. The degree of redness varied greatly, some swarms at Mahableshwar being far redder than some seen elsewhere.

Finally, when the coupling season came on, the red colour gave place to a general darker colour, with streaks of yellow. The ground colour in some was almost black, in others a deep brown ; there was a great variety in colour, but the general effect was to make the locust invisible on the ground. Locusts sitting on the ground within a yard's distance may escape notice till they move. This colouring apparently assimilates the insect to the wet ground so that it may couple and lay eggs undisturbed. There is no evidence that it was not "sexual colouring", but being common to both sexes and giving them an extraordinary resemblance to their surroundings, the rational explanation is that it is a protective colouration.

Such colour changes are not unusual in long-lived migrating locusts. The familiar grasshoppers of India do not change colour in this extraordinary manner, after they have once assumed the perfect form, and it may be assigned to the long life and extensive migrations of the locust.

PART III.

THE HABITS OF LOCUSTS, WITH METHODS OF DESTRUCTION.

It is convenient to recapitulate the periods of the locusts' life and discuss the methods which can be adopted for their destruction, based on their habits and conditions of life.

Flying Locusts.

The flying locust emerges from the grass lands in September and enters the crops. In ordinary years the locust then for the first time is observed, and as it immediately destroys the crops, any method of dealing with it is of great importance.

The daily habits of the locust at this time are as follows :— During the night it ordinarily remains motionless on the plants or on trees, not feeding and apparently numbed with cold. Should the nights be warm, it is active throughout the night and if disturbed drops to the ground and hops away. During October and early November it flies during the night, migrating from place to place. As the sun rises the locust becomes active and commences to feed ; about eight o'clock, it is sufficiently active to fly and may be driven along the crops, flying low and soon settling. At midday, it is flying aimlessly about in the air, feeding on the crops, and when disturbed circling overhead. About 5 P.M. it again settles down, and may be driven in any direction if the breeze is not strong. After that it settles down for the night. The practice of cultivators is to go into the fields and beat tins to frighten the locusts ; as a rule this has no effect except in disturbing the locusts and making them fly aimlessly from plant to plant. During October

1903, it was found possible to clear entirely a field of locusts by beating it through with a line of men ; the work must be done between 7-30 to 9-30 A.M. and 4-30 to 6-30 P.M. At no other time can the locusts be driven. This was effected with great ease ; the locusts could be driven out into waste lands or on to babul trees, and in most cases the locusts flew away the next night and were not seen in that village again. This is the only possible method of dealing with them at this time. Attempts were made to drive the locusts into patches of crops which were poisoned. The locusts were driven into such patches but the poison used was too strong and the locust flew away without feeding.

In November, when the nights become cold, the locusts are torpid and helpless at night and may then be destroyed. If they are in the crops, they may be driven out into any adjoining trees or waste lands. They prefer to sleep on trees in the cold nights, clustering on the top of the trees where the sun will strike them when it rises. From November to March, the method of killing the locusts at night when they are torpid is the only effectual one. The locusts then are active by day, usually migrating over the forests a distance of five to seven miles and settling about 5 P.M. in a compact mass on the trees. The simplest way to kill them is to form gangs of labourers armed with brooms, each under one leader, with a number of tree climbers attached to each gang. From 2 A.M. to 6 A.M. the gangs work, the climbers shaking the branches of the trees, the gangs below steadily beating the locusts to death as they fall down. The gangs work from different points and continue till daylight ; those locusts that are not killed by the brooms, gather on tree trunks, on bushes, in ditches and may be swept into bags as soon as they can be seen. The whole area treated is then swept up, the locusts piled in heaps and either burnt, treated with a solution of disinfectant, or buried. Many variations of this treatment were tried and none were so effectual as that described above. It is advisable to mark down at evening the exact spots where the locusts settle, as it is not easy to find the

best place to work at in the darkness. The same method is practicable in every village and when sufficient inducements offer, the villagers practise it successfully. From November to March, this method alone proves satisfactory, for it is impossible to destroy the locusts by day, as they are active and move readily. The same is true during the next two periods, the second migration and the scattering period. When the locusts are torpid at night they may be destroyed ; but when they are scattered over the country and no longer in swarms, they cannot be attacked on any large scale.

With the first fall of rain, the coupling period commences, and the locusts can then be caught by hand during the day, for they are sluggish and move little. In wet weather they sit on the bushes and may be caught in the hand. When actually coupling, children catch them easily and it is simply a question of offering a sufficient reward for a given quantity of locusts. Though they are then scattered, there are particular spots where they congregate in greater numbers, and where they may be caught fairly readily. This brings the flying locusts to an end, the eggs and hoppers alone remaining to be destroyed.

During the egg laying season it was expected that it would be possible to see locusts laying eggs in large quantities in special places, and that these locusts could be destroyed. This was found to be incorrect and there is little to be gained by trying to find locusts in the act of laying eggs. An egg-laying female can be approached and will not move if she has once commenced the actual deposition of eggs. As a rule about one to one and a half hour is required for the female to dig the hole for the eggs, and during this time she will immediately fly away if disturbed. After that, the actual laying of the eggs commences, and the locust will not move even if the soil is dug into beside her and the eggs laid bare. There is practically only a period of half an hour during which the locust can be found actually laying eggs.

During the course of continuous observation of locusts at Igatpuri, a considerable number of locusts were actually seen laying eggs, but this required a very great amount of

observation. At the best, not more than ten or twelve locusts would be thus seen in the course of a day.

Finding Eggs.

It is no easy matter to find any quantity of locust eggs except in specially favourable places. Continuous observation of coupling locusts showed that eggs were laid near the places where they coupled. There are no regular coupling grounds, and the utmost that can be said is that there are some spots which the locusts prefer both for coupling and egg-laying, and that in any village, when the locusts are most numerous, the eggs are likely to be found. It is useless to look for locusts laying eggs. Far more eggs are found by looking in the ground in what are likely to be the best places. The holes made by the locusts are characteristic, but are soon obliterated by rain. It is practically useless to look for any holes, so many beetles, crickets, etc., making holes of similar size. When locust eggs are laid and no rain falls, the hole, with its smooth even layer of light-coloured gum inside, can be seen readily ; in most cases rain falls and obliterates all external signs of eggs. The most satisfactory method is to scratch the ground with a strong knife or any small digging tool in those places most likely to contain eggs. In Igatpuri, with abundant locusts laying eggs, a fair number of clusters were found, but to find one hundred per day would have required ten to twelve hours continuous work in the best places. In other spots, larger numbers of eggs were found in exceptionally good places. On the whole, an experienced man with a good eye for locust eggs and an understanding of the best places to look for them would be lucky to find as many as one hundred egg clusters per day. (See also page 62.)

Where Eggs are laid.

It is found that locusts prefer certain spots for egg-laying and that the choice of these spots depends chiefly upon the quality of soil, the relative degree of wetness, the character of the vegetation on that soil and surrounding it

In the first place, dry soil is unsuitable and locusts in captivity absolutely refuse to lay eggs in dry soil. In a cage containing some wet and some dry soil, the eggs were all laid in the wet half ; locusts kept in a cage with dry soil die before laying eggs in the ground, the eggs being involuntarily laid on the sides of the cage a short time before death. This phenomenon is common with many insects which lay a large mass of eggs in one place, the physiological need of laying eggs overcoming the restraining force when the insects grow weak before death. Secondly, locusts will not lay eggs in waterlogged soil. Eggs were never found in places where water could stand, even if the other conditions appeared favourable. Nor would locusts in cages lay in absolutely waterlogged soil. Apparently a soil that is well soaked and drained is the first requirement. Thirdly, locusts rarely lay where there is much bushy vegetation shading the ground. In the lower slopes of the hills where a bushy jungle predominates, eggs are laid on the fringe of open spaces, or in the open spaces. Fourthly, eggs are laid freely in captivity in soil made up by hand and smoothed by watering. When the soil was again disturbed and not watered or rained on, no eggs were laid ; locusts apparently prefer an untouched smooth surface. Fifthly, locusts prefer the softer, less tenacious black soil to the stiff reddish clay soil, where both are well soaked with rain. This is probably simply a question of the ease of digging and of the danger in the clay land of the hole becoming waterlogged. The following lands contain the bulk of the eggs:—

(1). Rab lands, *i.e.*, land in which rab materials had previously been burnt, on which nagli (*Eleusine coracana*) or other seedlings were growing. Large numbers of eggs were found in rab lands and the locusts congregated in these rab fields among the seedlings. The soil here is loose and well drained, and the nagli affords food to the locusts. In the ploughed fields round these rab patches locust eggs were practically absent, unless the land had been sown or planted.

(2). Embankments of low-lying fields. In Igatpuri, eggs were found in the bunds of the rice fields though never in the

fields themselves. The top or the side of a bund offers a suitable place and a considerable number of eggs were found there.

(3). Grass land. Open land on hill sides, or grass land on the flat seems to be the favourite place for eggs. The grass strips between fields also contained eggs. In hilly country, the locusts remained on the lower slopes just above the valleys and eggs were extensively laid there. The grassy land with bush scrub was especially selected, possibly because the bushes afford food and cover from rain.

(4). Cotton and other fields. In the flat country of Rajpipla and Amraoti, eggs were found in the fields, usually near the edges close to a grass strip. On the whole, fewer were laid in such places. Fields recently cultivated contained no eggs, and only in fields where the surface was beaten flat with rain and a crop coming up were eggs found in any number.

On the whole it may be concluded that little is to be expected from looking for eggs or from offering rewards for eggs ; in exceptional places eggs will be found in some number, but where a large area is infested, practically nothing can be done with the eggs. In a later section, the effect of ploughing, etc., on eggs is discussed. It is interesting to note that locusts do not lay eggs freely in forest land but in open grass lands. Though the locust swarms live in forests, they appear to break up and seek the open grass lands before the coupling period commences. Thus it is that, when the swarms have broken up, locusts are found more readily in waste and grass lands bordering on forests than in the forests themselves. Waste lands in Belgaum and Dharwar probably contain the locusts that come out of the forests of the Ghâts in those districts and in Goa. An essential part of the locusts' movements would thus be the move out of the forest to lay eggs, with the corresponding move back to the forest when the new locusts become winged.

Hoppers.

Within five to six weeks of the eggs being laid the hoppers hatch. These live in the grass lands and feed upon grass and

other vegetation. Their life occupies some six weeks, during which time they are unable to fly and can only leap. They are active almost from the moment they hatch and commence feeding within an hour.

In this stage the locust can be destroyed only if very abundant. The hoppers do not pack into swarms and move over the country. They are stationary, finding abundant food where they hatch and remaining there so long as food is available. They are widely spread and practically infest the whole of the country in which they hatch. There is no way of gathering them together, and the method to be used must be one capable of being applied in every village over a vast area.

The experience of the 1883 campaign resulted in the discovery that bags were the simplest means of destroying hoppers. Further methods tried in 1904 were the American Hopperdozer, the Russian method, and the use of poisons. The Hopperdozer was abandoned on trial as offering no advantages over the bag in a country where manual labour and simple appliances are alone available. The Russian method, which consists in a revolving axle set with twigs, which brushes the hoppers into a bag, was found to be perfectly feasible, and would be eminently useful over large stretches of open country. For the cultivator a simple system is necessary and as the result of a series of experiments, the bag and frame described below was devised.

The frame used has an opening four feet wide, two feet high. The bag has the same opening, and is five to seven feet deep. When the frame can be drawn over the ground, it is so used. When bushes or other obstacles intervene, the bag is taken off, a bamboo placed in each side to hold it open, and two men drag the bag. (Plate VI., fig. 1.) For large stretches of open country, a longer bag is used with an opening 12 feet by 2 feet, and a depth of 8 feet. A useful pattern of bag was held open by four bamboos, the horizontal ones forming handles; the mouth of this bag closes automatically if the bamboos are not lashed but fastened by a

bolt passing through the two bamboos. (Plate VI., fig. 2). The following leaflet was published in English, Gujarati, Marathi and Hindi describing this appliance :—

Methods for Destruction of Hoppers.

Experiments made in destroying hoppers have shown the following method to be simple and efficacious. A bamboo frame is prepared as in the directions given below ; to this is attached the bag also described below, which has an opening four feet by two feet, which is kept open by the frame. Cords are attached to the frame and it is drawn rapidly over the ground. Hoppers get into the bag and periodically the bag is taken off, twisted up and the hoppers inside crushed.

The frame and bag is so light that one man can easily draw it rapidly up and down, sweeping up the hoppers. This method is available in grass land, in young crops, wherever the growth of vegetation is not too high. In cases of crops, bushy land, etc., the bag may be detached from the frame, two bamboos placed at the sides of the mouth and the bag drawn by two men with cords. It can then be drawn through and over crops, grass, bushes, etc., and is extremely easily manipulated.

These two methods of using the bag should be sufficient to destroy hoppers in large quantities in almost all kinds of land. For use in large areas of grass lands or crops, larger bags can be prepared and used without frames, simply with bamboos placed at the sides to keep the mouth open.

The dimensions given are those found handy for one or two men's work. Large bags for open lands may have an opening of twelve feet wide, two feet high, and a depth of eight feet. In this case the bag should be weighted with pockets of sand sewn into the lower edge of the mouth and the corners of the back. Two men can manipulate such a bag and cover a large area of land.

To make a Bag and Frame with opening of four feet by two feet.

Sufficient strips of cloth are taken, each fourteen feet long, sewn together by their long edges to make a piece fourteen

feet by six feet. The two ends are then brought together and the sides sewn up. This makes a flat bag, to which strong cloth tags are sewn, the first at one seam, the next two feet from that, the third four feet from the second, the fourth two feet from the third and four feet from the first. Bamboos of two feet length are fixed between the two pairs of tags two feet apart and the bag is ready. (Plate VI., fig. 1.)

The frame is made of four pieces of bamboo, (*a*) each four feet three inches long, laid in a square, the ends of two bamboos on the ends of the other two. Two cross pieces (*b*) of split bamboos, each five feet eight inches long, are laid diagonally across the square. Two pieces of bamboo, each two feet three inches long (*c*), are placed upright at the corners of one side, and two split bamboos (*d*), each four feet eight inches long, are placed from the top of these uprights to the nearest corner. A cross bar (*e*), four feet three inches long, is then placed to unite the top of the two uprights. (Plate VI., fig. 2.)

As the bamboos are placed in position they are bound with string or fibre in the order given above. Enough bamboo should project at the ends to allow of their being bound together. This makes a frame to the front of which the bag above is attached by the tags.

In these figures, three inches extra length is allowed to permit of the bamboo being bound; the resultant frame is then of the size to accommodate the bag. The two feet long bamboos used for keeping the bag open are inserted only when the bag is used alone; when the bag is attached to the frame, these bamboos are removed and the tags of cloth knotted to the frame, so that the bag can be at once removed and twisted up. In place of bamboo, strips of wood may be used.

Rewards.

The question of the amount to be offered for locusts and locust eggs is one that can be answered only from a consideration of local circumstances. For winged locusts during the cold weather $\frac{1}{4}$ to $\frac{1}{2}$ an anna per seer (2 lb.) was sufficient to give a

fair wage to an active man. Later when the locusts were coupling and it was important to destroy them, ½ to 4 annas per seer was paid. A seer of locusts contains about 450, or about 400 in the coupling season. A seer of eggs contains about 1,000 eggmasses, from 100,000 to 120,000 eggs. As one egg mass is about one-third the weight of a female locust or one-fifth of the pair of locusts, 5 seers of locusts are required to be equal to one seer of eggs, and every five seers of locusts killed in the coupling season is equivalent to one seer of eggs destroyed. The reward for eggs was accordingly fixed at rupee one per seer. The average weights of the locusts are :—

	Grains.	Per seer.
Male	25-30	640-466
Immature Female	30-35	466-400
Mature	40-45	400-350
Egg-cluster	12-15	1170-1000

Food Plants.

The locust swarms on first emerging fed principally upon *juari* (*Andropogon sorghum*) and *tur* (*Cajanus indicus*), and though cotton was abundant did not touch it even when they were driven into the fields of cotton. Bajri (*Pennisetum typhoideum*) and other millets were eaten, as well as sugarcane to a slight extent. Oilseeds were not seen to be eaten but the Director of Agriculture, Bombay, informs me they eat oilseeds in the Ahmedabad District. Mango and citrus trees were extensively eaten, also the cocoanut and toddy palms. During the early rains of 1904, the seedling *nagli* (*Eleusine coracana*) was much eaten. Large numbers of forest trees and many bushes are eaten, though they prefer certain kinds when they can be obtained. The 'neem' *melia azidarachta* is one tree that is apparently little eaten.

Dead Locusts.

When locusts die, decomposition causes the usual odour in a few hours. This attracts numerous insects, which feed

upon the corpse and destroy it. These insects include ants, Scarabeid beetles, (*Onthophagus spp.*) and Histerid beetles (*Hister spp.*)

The ants carry off the carcase in pieces and feed upon the decomposing interior. The Scarabeids feed upon the decomposing interior and retire into holes in the ground which they make below the corpse. The Hsterids feed also on the interior of the corpse. The result of this is that a dead locust vanishes in a few hours and when the locusts are dying off in large numbers, such is the rapidity with which they vanish that it is correctly said they disappear; careful search during the time locusts were dying, showed that moribund and dead locusts were to be found as would be expected, but they vanished so soon that only careful observation would show that they were dying at all. Fifty locusts put on the ground in the evening vainshed by next morning. Similarly dead locusts thrown out of the cages in the morning disappeared during the day.

Locusts in Cages.

Locusts live well in cages, if looked after carefully and fed well. The best pattern of cage is six feet high, and at least four, preferably six, feet square. The sides may be wire gauze, the top wood. A door should be placed in one side occupying the whole or half of it. Such a cage can be put down anywhere and food grown on the soil for the locusts beforehand. It is advisable to paint the whole cage with arsenic solution or some other compound to preserve the wood-work from white ants and the gauze from excessive rusting. For obtaining locust eggs and keeping them under observation, smaller cages which fold up, can be used. Those used in this investigation were three feet cube, the top of wood, the sides of wood and wire gauze. (Plate XIII.) Each two sides are hinged and fold back, fastening together with hooks when set up. A door one foot wide stretches up the middle of one side. Eggs are laid in such cages either in the ground or in boxes of earth. Green food must be given twice daily. The common squirrels will do

their utmost to break into such cages if they contain locusts, and the wire gauze should be well fastened down, with strips of wood and not simply tacked.

Enemies of Locusts.

The Bombay locust suffers from the attacks of enemies which lessen its numbers and form a natural check upon its increase. It is difficult to estimate the relative importance of these checks or their gross aggregate effect upon the swarms.

The common grey-necked crow feeds upon adult locusts at all times; when the swarms move about in the crops during September and October, the crows congregate in great numbers to feed upon locusts. Moribund locusts that had been treated with insecticides and were comparatively helpless were snapped up eagerly, the crow then not having the trouble of chasing his prey. Egg-laying locusts also were constantly preyed upon, the crows sitting on trees near the *rab* lands, waiting till a locust settled down to lay eggs.

Monkeys are fond of locusts but are probably not numerous enough to make any effect. If the "Monkey test" is of any value, locusts should be good food for man.

The common striped squirrel is also fond of locusts and eats them at every opportunity. This is the chief difficulty encountered in keeping locusts in cages, as squirrels will do their utmost to break or tear the wire gauze.

Two parasites have come to light, one internal, one external. Locusts have been found in Rajpipla, in Ahmednagar district and other places, infested with large maggots, which live in the abdomen and feed upon the tissues. Specimens were forwarded by the Political Agent, Bhopawar Agency, who said—"The disease apparently commences just above and behind the hind leg of the locust and the maggots spread thence throughout the body". Such flies are common parasites on insects ; it is impossible to estimate the value of this insect, as most of the infested locusts would be killed and not be seen. A similar parasite (*Miltogramma duodecim—punctata*) attacks the migratory locust, *A. peregrinum*.

The external parasite is a minute scarlet organism, which clusters on the lower wings. In some districts the cultivators believe these to be the eggs. Specimens were sent to R. I. Pocock, Esq., Zoological gardens, London, who identified them as the young of *Trombidium grandissimum*, the large red velvety mite. This mite has been found laying eggs in large masses in the ground beside the eggs of the locust ; the young are common on many insects and spiders and lead a parasitic life in their larval stage.

Eggs are attacked by at least three distinct organisms. The first is a beetle grub, a yellowy white insect with three pairs of legs found in the centre of egg clusters, feeding upon the eggs. This grub eats the eggs, remaining in the egg cluster till all are devoured, by which time it is nearly one inch in length. Of the many eggs found, a very small percentage are thus attacked. Eggs in damp soil are attacked by a minute white worm, scarcely visible to the naked eye. It is found in great numbers in egg clusters, but only a very few have been found to be attacked. This worm is to be described as a new Enchytraeid worm.

The third is an ichneumon (*Scelis indicus* Ashm.) which lays one egg in each locust egg. Specimens were reared from eggs collected in Igatpuri, only part of the egg cluster being affected, the remainder hatching normally. Specimens from Peint and Sindked (Khandeish), were also sent in by Mr. J. B. Knight, Special Assistant, Department of Agriculture, Bombay.

The common grey-necked crow also feeds upon eggs, digging them out of soft ground with its beak. Suspicion attaches to certain beetles, but no confirmation could be obtained of the fact of their destroying sound eggs.

The Effect of Weather on Locusts.

As the Life History of a locust occupies one year, it thus passes through the various temperatures and alternations of wet and dry weather that occur in Western India. It may be said that weather is normally without effect on eggs ; eggs are laid only after rain has fallen and chiefly in places where wet

weather is continuous from the beginning. Rain is without effect on eggs, as long as they are laid in a place whence the rain drains off and does not stand. Even when exposed without covering to heavy rain at the top of the Western Ghâts, the eggs remain healthy. As eggs are not found in places where water stands, it may be said that rain is without effect on them. Not so dry weather; during the first three weeks eggs that become even moderately dried, shrink and die. Even in the intensely moist air of the Ghâts, undeveloped eggs kept in the air away from actual rain shrunk up and did not hatch. The same is true of eggs in soil that is allowed to dry. When the development has proceeded, the egg being some three weeks old, dryness is without effect. During the last half of the period, eggs may be kept dry, and yet will hatch readily and freely. Below are given the dates of hatching of eggs treated in various ways. It is noticeable that eggs kept water-logged for some days when first laid, if afterwards allowed to dry, hatched. Also that eggs kept throughout in very moist soil, whether actually water-logged or not failed to hatch. This is possibly due to asphyxiation of the eggs kept in captivity for experiment; those that hatched best and most speedily were kept moist and allowed to dry in the second half; the soil was loose and porous and the hoppers had no difficulty in obtaining air.

We may conclude that (1) eggs are unaffected by rain, but do not hatch if kept in water-logged soil throughout; (2) eggs exposed to rain, without sun, hatch; (3) undeveloped eggs exposed to the air and not wetted, die; (4) in the early stages, eggs exposed to sun for one day are killed; (5) dryness in the second half facilitates the hatching.

The following were the facts elicited from the experiments with eggs in 1904:—

Eggs laid in earth and exposed to all weathers and kept moist, seventeen clusters hatched and ten died.

Eggs laid in earth and exposed to sun without water, all died.

Eggs laid in earth and kept moist without exposure to sun, fifteen out of sixteen clusters hatched.

Eggs laid in earth and kept under shelter in the damp air of Igatpuri for the first half of their incubation, five out of eleven clusters hatched.

Eggs laid in earth and kept under shelter without water for the whole of their incubation in the dry air of Surat, all died.

Eggs laid in earth and then covered with water for varying periods, two out of five clusters hatched.

The period of incubation of eggs laid in earth and exposed to all weathers, with the addition of water when necessary, was shortest (39 days) at Surat and Shahapur, was longer (42 days) when the eggs were for the first half at Igatpuri and for the latter half at Surat, and was longest (55 days) when kept for longer periods at Igatpuri. This is probably due to differences in temperature. The degree of moisture appears also to have an effect on the period, as eggs kept dry at Surat hatch later than those kept damp under the same conditions at Surat, and this is true also of eggs at Igatpuri.

Locust Egg Clusters.

	Hatched.	Failed.
I. *Laid in captivity in Earth.*		
Kept dry in shade	5	7
Kept dry in sun	.....	3
Kept damp in shade	15	1
Kept damp in all weather	17	10
Waterlogged three days	.....	2
,, one day	1	.....
,, one week	1	.....

II. *Collected.*

Eggs kept dry under shelter in earth failed.

Eggs kept in earth with rain or sun, kept damp, all hatched.

Eggs in a box without soil died, unless the incubation was advanced, whether kept damp or dry. If the eggs were new, they went mouldy if kept damp. If near hatching, the drying facilitates the hatching.

TABLE I.

Eggs laid and kept exposed to sun and rain.

Locality.	Date Laid.	Date Hatched.	Period in days.	
Surat ...	20 VI	25 VII	35	
,, ...	20 VI	31 VII	41	
,, ...	20 VI	1 VIII	42	Average 39 days.
Shahapur ...	27 VI	6 VIII	40	
,, ...	29 VI	1 VIII	35	
Igatpuri I ...	23 VI	15 VIII	53	
,, ...	22 VI	16 VIII	55	
,, ...	22 VI	18 VIII	57	
,, ...	26 VI	17 VIII	52	Average 55 days.
,, ...	26 VI	19 VIII	54	
,, ...	26 VI	24 VIII	59	
Igatpuri and Surat ...	1 VII	2 VIII	32	
,, ...	6 VII	15 VIII	40	
,, ...	6 VII	18 VIII	43	Average 42 days.
,, ...	8 VII	25 VIII	48	
,, ...	13 VII	27 VIII	45	
,, ...	13 VII	29 VIII	49	

TABLE II.

Eggs kept damp under shelter.

Locality.	Laid.	Hatched.	Period in days.	
Surat ...	20 VI	10 VIII	51	
Igatpuri ...	23 VI	10 VIII	48	
,, ...	24 VI	14 VIII	51	
,, ...	26 VI	16 VIII	51	
,, ...	26 VI	18 VIII	53	
,, ...	26 VI	18 VIII	53	
,, ...	26 VI	18 VIII	53	
,, ...	26 VI	18 VIII	53	
,, ...	26 VI	17 VIII	52	Average 51·6 days.
,, ...	26 VI	19 VIII	54	
,, ...	26 VI	20 VIII	55	
,, ...	30 VI	21 VIII	52	
,, ...	30 VI	22 VIII	53	
,, ...	30 VI	22 VIII	53	
,, ...	5 VII	26 VIII	52	

TABLE III.

Eggs laid and kept dry under shelter.

Locality.	Laid.	Hatched.	Period in days.	
Igatpuri .	26 VI	8 VIII	43	
,, ...	22 VI	28 VIII	67	
,, ...	26 VI	18 VIII	53	Average 55 days.
,, ...	26 VI	20 VIII	55	
,, ...	23 VI	20 VIII	58	

Hoppers.

Neither rain nor sun affects the hoppers. The heaviest rains appear to be without effect on hoppers, nor does sun in any way affect them so long as they have food. It is generally believed that a heavy monsoon kills the hoppers, but no foundation for this belief can be traced.

When rain does not fall in sufficient quantities to produce abundant moist grass crops, the hoppers die. This is readily understood, since hoppers require large quantities of fresh green food, the moisture in the food being their only supply of water. It was also found impossible to rear hoppers unless in a moist atmosphere ; where the air is dry, the green food soon dries up and the hoppers then die. So sensitive are they, that it was found impossible to rear hoppers at Surat during the dry weeks of 1904, except in large glass bottles ; in cages the hoppers died off rapidly in spite of a liberal provision of green food and damp earth. In 1905, a single hopper was reared without any difficulty in the damp air of Pusa in an open cage.

Locusts.

The *flying locust* emerges during the warm weather at the close of the rains and is unaffected by high temperatures. The steady high temperature of the Western Coast has the effect of keeping the locusts active day and night if necessary.

From October to June, there is little rain and when the heavy rains come, there is no effect save that of the immediate coupling and laying eggs. The heavy rains of the Ghâts are without other effect on them ; when a rain-storm comes on they settle on bushes or trees, and are in no apparent degree affected.

The effect of the rain in producing coupling and egg laying is probably a secondary one, in that they then are able to lay eggs in the wet ground, and they live till the rains for that purpose. It cannot directly be assigned to the effect either of rain beating on them and gradually killing them or to any direct physiological effect. The significance of the first fall of

rain is one that must not be lost sight of ; locusts will apparently not couple or lay eggs until rain has fallen. When the rain falls in sufficient quantity to penetrate a few inches into the soil, the locust couples and lays eggs. Should the locusts be in a place where rain is much delayed, they may die or may be able to live for some weeks only until rain comes. Such a contingency seems to have occurred in 1904, and it may be a very important factor in naturally checking the increase of the locust. So long as the locust can remain in the Ghât forests, and find plenty of food, it is likely also to find sufficient rainfall in June. But if pressure of numbers drives them forth into the arid Deccan, and the rain delays at all, the effect may be very great. During 1904, the locusts on the Ghâts were dead by the 20th July. Scarcely one could be found. Yet at that date, many could be seen in the Central Provinces and Behar, and with the later arrival of rain there, coupling, egglaying and dying were all correspondingly delayed. This point is one of great importance in fixing the approximate dates of egglaying and appearance of hoppers. It is stated that locusts are more abundant after a year in which the rains are late than in a year of normal rain, and it is believed that the heavy rains destroy the small hoppers, the latter growing large enough to resist the rains when the monsoon bursts late. This is opposed to the experience of this year ; rain is without effect upon hoppers of all sizes and the explanation may be sought in the better hatching of eggs in a dry year than in a wet one, provided enough rain falls to allow the locusts to lay eggs and to keep these eggs damp in the first three weeks. Thus a light rainfall in June, with occasional showers until August, would appear to give the ideal conditions for locust eggs ; and this means that from the point of view of the crops, the rain only falls in August. The evidence of 1903 certainly shows that a heavy rainfall in July and August is without effect on hoppers ; in South Gujarat rain fell in late May and early June, the locusts subsequently disappearing as they would naturally do after laying eggs. Heavy and continuous rain fell from July 12th onwards, and subsequently immense

swarms of locusts appeared over this area. The explanation most likely is that the light early rainfall facilitated the hatching of eggs, and it may be considered probable that this accounts for the concurrence of late rains and many locusts.

The Effect of Insecticides on Locusts.

Insecticides act in three ways on insects, through the stomach, through the skin or spiracles, and through the respiratory system. With so large and active an insect as the Bombay locust we should use a stomach poison if possible as being the most reliable, and use arsenic as the best stomach poison. Arsenic can be used in two ways, in solution in water or as an insoluble compound.

Both have been tried on locusts in captivity: locusts were fed with (1) fodder dipped in the standard lead arseniate wash, *i.e.*, 1 lb. lead arsenate, 5 lb. jaggery, 100 gals. water. (2) Fodder dipped in sodium arsenate 5 lb., jaggery 40 lb., water 200 gals. (3) Natal locust mixture, on fodder and in a saucer. The first killed eighty per cent in 12 hours, the locusts feeding on the fodder. The second and third killed none, the locusts declining to feed on the fodder or to drink any of the mixture. It may be pointed out that in (1) the mixture is insoluble, probably not tasted by the locusts and the same as used in crops for other insects: in (2) and (3) there is a large proportion of soluble sodium arsenate, that might taste unpleasant and deter the locust from feeding: also the solution is very strong and syrupy. In all cases locusts refused the strong solutions and were killed by the weak solution. The question of using arsenic as a poison for locusts has been tried in many countries, and in Natal considerable success has resulted from the use of arsenical mixtures as poisons. The chief objections to the use of arsenic in India are (1) the danger to cattle if the arsenic is strong enough to poison them, since the mixture, if to be used generally, must be used freely and without careful supervision; (2) the difficulty of obtaining and distributing it over large areas; (3) its application.

The Natal locust mixture contains 1 oz. of caustic soda, 4 oz. of white arsenic, 4 oz. of ground valerian root, and 80 lb. of jaggery or sugar in every five gals. of mixture. It is a thick syrupy solution containing soluble arsenic. It is highly poisonous to cattle. It requires care in its preparation and will kill living plants on which it is placed. Its use would be for painting or dipping forage which would be placed in the fields where the locusts would find it. It failed absolutely with Bombay locusts when applied to juari plants, when put on bundles of grass and juari in the field amidst a swarm of locusts, and when fed to locusts in captivity.

Arsenic as used on crops is used in an insoluble form, in very weak strength in water. It poisons locusts in captivity, and does not poison cattle. A number of experiments were made by Captain Walker, M.R.C.V.S., Punjab. His notes are reprinted and sum up the question of poisoning cattle.

Copy of a report by Captain G. K. Walker, Indian Civil Veterinary Department, on the result of experiments with the arsenical solutions, during the year 1903-04.

I have been able to do some feeding experiments with arsenical solution on cattle. I have not been able to give much time to the work and the experiments are not so complete as I should desire ; still they are useful.

I first tried the solution recommended by the Natal Entomologist (Agricultural Journal of Cape of Good Hope, January 1903). The formula being 1 lb. of arsenic to 10 gallons of water. White arsenic ($As_2 O_3$) from the bazar was used and washing soda and ghoor (instead of treacle) employed in addition. It may be said that as a dissolving agent washing soda seems quite useless, and although the arsenic appeared to be dissolved when the water was raised to boiling point, when the water cooled, very little, if any, appeared to have dissolved.*

This is very objectionable as if used it can be readily seen that an animal might receive a large quantity of undissolved salt with a relatively small quantity of fodder and an unequal distribution of the arsenic cannot tend to success.

Mr. Lefroy seems to think that undissolved arsenic though harmful to locusts will not hurt animals. This is an erroneous idea, arsenic in any form is very poisonous to cattle and being an accumulative poison continued doses harmless in themselves, eventually cause symptoms of poisoning.

* It requires continued boiling to dissolve [H. M.-L.]

To return to my experiments—a bullock was given 12 seers of churry (jowar) on the leaves of which some of the solution was painted with a brush. This animal was vey ill next day with some symptoms of arsenical poisoning, and was found dead on the third morning after. About two pints of solution were used, and it is possible the animal may have received as much as three drams of arsenic, presuming none of the solution was spilt in the application. Ten grains is a full medical dose for cattle, so the result is not to be surprised at. I made a post-mortem and tested the contents of the stomach, in which I found arsenic in considerable quantity.

It is true the animal was a miserable half-starved creature, but this added to the value of the experiment as the conditions were natural.

The same remark applies to the subject of the next experiment.

I next tried the formula given in Indian Museum Notes IV, No. 3, 1899, p. 139, which is a much weaker solution, *viz.*, 1 lb. to 32 gallons. The dissolving agent in this case is caustic soda. I used caustic potash which is easier to get, and the arsenic dissolved easily and did not precipitate on cooling.

The bullock had 32 oz. of solution painted on 16 seers of churry. He left about five seers of this and was very ill next day with symptoms of poisoning, in fact he looked like dying, so I ordered antidotes to be given to save him.

If he had eaten the whole 16 seers he would possibly have received as much as 96 grains of arsenic (as the maximum quantity).

This bullock is still alive (8-12-03), but very ill in spite of antidotal medicine. I fear he will die.

A fowl fed on grain soaked in the solution is still alive and shows no symptoms of poisoning.

Owing to the necessity of leaving headquarters to-morrow the above is as much as I have been able to do.

It is obvious that very serious danger to cattle is to be apprehended if crops to which they have access are sprayed with arsenical solutions.

No doubt, many cattle would feed with impunity,because I fail to see how one can ensure an even distribution of the fluid, and it is certain that much would be wasted. It is unlikely that animals in the ordinary course of events would be allowed to eat a standing crop for a sufficient number of consecutive days, to obtain a poisonous dose, if the solution used was a very weak one, as presumably only stray cattle would be allowed to eat the crops in this way.

When however the crop is cut it would probably, in many cases, be used as "Chop" or Bhoosa, and the arsenic would still be there. I should apprehend chronic arsenical poisoning if the animal were fed for any period from a sprayed crop, and the symptoms would be more of a debilitating disease. Poisoning might not be suspected owing to the gradual course of the disease, but the fact would remain that arsenic caused the mischief.

Chronic arsenical poisoning is met with in the neighbourhood of the tin and smelting furnaces of Cornwall and Wales.

Animals vary tremendously in their susceptibility to arsenic, large doses have little effect sometimes, and small doses will often act with great violence especially if given for many consecutive days, owing to the accumulative nature of the poison. The death of a horse is recorded from arsenical poisoning from a dose of five grains daily for eight days; 30 grains a day killed a horse in four days. According to Mr. Lefroy's estimate of 20 grains a maund, it would be possible for a bullock to receive about 10 grains a day.

This if continued long enough would certainly cause symptoms of poisoning.

I am inclined to think that spraying crops with arsenical solutions especially if left in the hands of irresponsible men would be very dangerous to cattle. I am disposed to recommend a trial of the system advocated on page 85 of Agricultural Journal of Cape of Good Hope, January 1903, in which horse dung and arsenic is the bait.

This would have to be put down in fenced off places or raised off the ground and buried when done with. Animals (cattle) though not partial to horse dung might pick it up especially if flavoured with sugar; and would have to be prevented from gaining access to the bait.

Copy of a Note from Captain G. K. Walker, Superintendent, Civil Veterinary Department, Provincial Circle, to W. C. Renouf, Esquire, Director of Land Records and Agriculture, Punjab.

I have made a further experiment on a bullock as you required with the arsenical solution recommended by Mr. Lefroy, *i.e.*, a solution of lead arseniate paste (1 lb.-100 gallons of water, plus 10 lb. of jaggery).

The arsenical paste is soluble in hot water, but a sediment is thrown out when the water becomes cold. Careful stirring is therefore necessary before using the solution.

From the 24th January to the 1st February the bullock received 8 seers of green oats in the morning and 8 seers of green oats in the evening.

The morning feed was painted with the solution, about 12 oz. being used, but the evening feed was given fresh. From 2nd February onwards both feeds were painted, and the amount of solution used 24 oz. a day.

The experiment was discontinued on 23rd February, the animal being in perfect health.

In 30 days therefore the bullock might have received about 5 drams of lead arseniate presuming none of the solution was lost in the application.

I might say that in face of the above experiment and taking into consideration the strength of the solution, I consider it very unlikely that any harm is likely to come to cattle that may happen to feed moderately on crops sprayed with Mr. Lefroy's solution.

If arsenic can be used to poison locusts, it would seem better to use the weak solution of lead arseniate, which will have no ill effects when once applied to plants. I do not anticipate any value in its use against the Bombay locust. For hoppers, it would have to be applied in large areas of grass land, and would wash off with rain. The hoppers do not pack into swarms and eat down a field; were this the case it could be used and would kill many. For flying locusts if it could be applied to juari fields for instance, the locusts would be poisoned if they stayed there. When the locusts first emerge, the fields they come into could be poisoned. Lead arseniate can be applied safely only in water. It can be applied in powder, but only extremely careful application could guarantee that cattle would not be poisoned. Facilities for applying washes on crops are practically non-existent in India, and the cost of introducing them in sufficient number would be prohibitive. Later in the season, the arsenic would have to be applied to forest trees. This is an easy matter, given the appliances, labour, and a supply of water and arseniate. When it is a question of treating an area of 12,000 square miles of forest country, the enormous cost immediately puts the matter out of consideration. Contact poisons have suggested themselves as a mechanical means of destroying locusts gathered in large quantities on the trees. Captive locusts sprayed with ordinary kerosene emulsion, die after 24 hours, probably because they are unable to fly and dry the mixture off their bodies. The same occurs far more rapidly when sprayed with McDougal's Sheepdip (1 lb. to 3 gals. of water). Locusts in the field, sprayed with the latter mixture, are found dead in 12 hours if sprayed in the evening, and when sprayed in the morning they die in the course of the day. Pure kerosene sprayed on them has the same effect. As a substitute for Sheepdip, McDougal's Sanitary Fluid at 1-20 has been used, and locusts so sprayed die in the course of the day This contains crude carbolic (as creosote oil) and the carbolic is the killing agent in all probability.

Kerosene is the only other substance that suggests itself as a useful killing substance.

The contact poisons commonly used for insects include kerosene, rosin, tobacco, sulphur and lime, soaps ; carbolic cannot as a rule be applied to plants but is a good contact poison, as is creosote. Of the standard insecticides, crude carbolic preparation, sold as "Sanitary Fluid" combines efficiency and low cost. As a result of investigations with different forms of crude carbolic preparations, the ordinary "Sanitary Fluid", a dark black or green soapy fluid, has been found to be the best. Kerosene and rosin preparations are effective at great strength, but are tedious to prepare and costly. Sanitary Fluid costs about Rs. 10 per 5-gallon drum, sufficient to make 150 to 200 gallons of wash as actually applied. It is readily obtained in large quantities. The question of using insecticides for locusts is discussed elsewhere ; no advantage is likely to be derived from their general use. Vapour poisons are entirely out of the question either against hoppers or flying locusts.

PART IV.

THE LOCUST PROBLEM.

The Bombay Locust in September 1903 probably occupied an area of not less than 25,000 square miles ; during the winter months it was concentrated in an area of 12,000 square miles and it then dispersed over an area which cannot be less than 140,000 square miles. To deal with a migratory insect that moves over such areas of country is not a light matter, and the experience of this outbreak will be of great value when the next commences.

In all probability, there will be no warning of the next outbreak until the flying locusts emerge as they did in September 1903. During the rains of 1903, there must have been numbers of hoppers throughout the area in which the swarms originated and there is no more likelihood that the hoppers will be seen in another year than they were in 1903. In discussing the general measures possible against the locusts in another year, it is convenient to commence with the flying locusts as they come out of the crops. Wherever locusts are found in September or October, whether in Bombay, Central Provinces, Madras or Central India, the most accurate information possible should be obtained as to the size of the swarms and their movements. During 1903, the swarms came largely from South Gujarat, with a contingent from Goa and Khandeish ; in 1904, the eggs were laid and the swarms would have started over a far wider area, if the climatic conditions had been favourable to the eggs hatching. It is, therefore, not possible to say that the swarms will originate in any particular part of the country ; their natural and normal breeding place appears to be the forest region of the Ghâts and that neigh-

bourhood ; in exceptional years they spread over a larger area, as they did in the early part of 1903, and again in 1904. If the swarms return, as they did in 1903, into the Ghât forest region, they have to be attacked there ; whatever their movements, it will be important to know where they are and in what direction they move.

During September and October, little can be done ; the villagers should be induced to come out and beat the swarms from the crops in the manner described on page 20. Continual harrying may drive the locusts from place to place, till they reach the forest regions, where at least they will not destroy the crops. They cannot be destroyed in these months on any large scale, and the one thing possible is to keep them moving, to drive them into waste lands, and worry them till they leave the fertile areas for the forests. During the cold weather, the method of destroying them at night can be followed wherever the locusts are accessible. Places like Mahableshwar and Satara form centres for this work, and in every village efforts should be made towards killing the locusts under the stimulus of a proper reward and an active officer. There are at least four months during which this can be done, when the locusts are concentrated in a smaller area and are perfectly helpless at night. After this comes the migrating period, during which nothing can be done except to attack them at night as before. The coupling season offers the last hope of destroying them before eggs are laid ; there is little difficulty in collecting them by day and every pair of locusts then killed means one egg cluster less laid in the ground. The utmost care should be taken to compile accurate records of the places where the locusts lay eggs, that is, of the districts where locusts are at the coupling and egg-laying season. Though it is not generally possible to destroy eggs, it is possible to destroy hoppers, and no better or easier method offers itself of checking the locusts than that of destroying the hoppers. If large swarms of locusts are known to live till the coupling period and are then marked down, it may be possible to destroy hoppers on a large scale when they emerge later in the season and so

check every outbreak at the commencement. The action necessary amounts to—

(1) Note the movements and size of the swarms during the first migrating period.
(2) Urge the villagers to drive them out of the crops.
(3) Destroy them at night during the cold weather.
(4) Destroy them during the coupling season.
(5) Mark down the localities in which they couple and lay eggs.
(6) Destroy the emerging hoppers.

In view of the many printed papers issued by the Government of Bombay during the year, comment on these points and on their execution is not much needed. The experience of 1903-1904 has elucidated much, and notably certain practical points which would have been of great value had they been known before the outbreak of locusts.

In regard to the first point, the very practical caution of ascertaining the identity of the locust may be impressed. In 1903 the migratory locust was also passing through Gujarat and was confused with the Bombay locust. The past records bristle with difficulties and misconceptions due to the impossibility of accurately identifying the locusts or to the chance assumption that the locust in question was "Acridium so and so."

Various methods of carrying out the third point were advocated and tried. The use of fire in any form was eventually abandoned, as also the use of kerosene torches. Insecticides are extremely valuable when they can be applied, but the expenditure of large sums on machinery and insecticides, while useful for the protection of stations such as Mahableshwar, is not likely to solve the general problem. It has been shown that twelve men with insecticides destroyed ten times the number of locusts killed by hand with a large gang of labourers in far less time, and at far less cost ; but the difficulties of transport and of water-supply, and the absence of men fit to carry out this work put this method beyond consideration. The method of killing locusts at night was fully successful at

Mahableshwar, and was largely adopted during subsequent operations in many parts of the Bombay Presidency.

During the coupling season, no special methods are needed. The offer of rewards, and the encouragement by village officers and mamlatdars should stimulate the people to collect the locusts and the only thing needed is a supply of bags in which to bring in the locusts.

The destruction of hoppers by means of bags and frames was tested on a sufficiently large scale to demonstrate its fitness for general use, and more complicated methods are not likely to offer any advantages. The Appendices contain papers relating to the measures adopted and their efficacy, which will be of value in the future.

The Permanent Habitat of the Locust.

The outbreak of locusts in 1903-1904 was an exceptional phenomenon due to conditions not fully understood. It is comparable with that of 1883, and we may anticipate such outbreaks periodically, though not at regular intervals.

It is not possible to say to what causes this outbreak was due. The natural increase of the locusts yearly would be fifty fold if none died. A single swarm alive in May would, if conditions were suitable, produce fifty swarms by the following October. It is thus evident that there are natural checks on the increase of locusts, as there are on the increase of all insects. These checks appear to be climatic conditions and parasites or enemies. The first is probably the most important and, perhaps, solely responsible for the fact that locusts cannot increase beyond a certain number, and is operative principally when the locusts reach a large number. The second is a permanently acting check, which is not wholly efficient and can never be expected to be. Natural checks of this kind act in waves, the great increase of the parasites or enemies producing so great a diminution in the number of locusts that automatically the parasites perish for want of food and the locusts again increase. We may expect an alternation of few and many locusts if we look to natural checks alone.

The matter cannot be fully understood until we have longer experience of the habitat of the locust. So far as our present knowledge shows, the Bombay locust is dependent upon forest areas for its food during the time it forms swarms (November to April). The forest areas of Kanara, Goa and neighbouring districts would seem to be its permanent habitat during this period in normal circumstances. In this region it commonly abounds in swarms. In other forest areas also it may frequently occur in swarms, but so far as is known these areas are confined to the Western half of the peninsula. In other parts of India it occurs in small numbers, being either carried in exceptional migrations as that of 1904 or normally breeding there. We can anticipate small swarms originating in any forest areas in Southern and Central India, but possibly the forest areas are not large enough or not suitable for the production of large swarms except on the Western Ghâts. Accepting the Kanara and Goa forests as the normal habitat, we know that in ordinary years, the locusts breed in open grass lands or waste lands in or near these forests, including Dharwar, Belgaum, Hyderabad, Mysore and Kanara. The new broods of locusts that fly in October appear then to return to the forests. In years of greater increase, the swarms in these forests appear to spread further afield, either for food or for breeding. They then occur in the Western Ghâts as far north as the Dangs and enter Gujarat. Whether they also go into Mysore, Hyderabad or Madras territory in any numbers is not known. This apparently occurred early in 1903, the locusts that arrived in the Dangs and Gujarat in April 1903 giving rise to the swarms of October 1903. In this case the first spreading of the locust swarms was followed by a large increase, due either to the absence of parasites and enemies, or to favourable climatic conditions. In other years it is possible that the spreading of locusts is not followed by large increase, probably owing to unfavourable climatic conditions. In this connection we may ask what happened to the progeny of the 1904 swarms which spread over so vast an area. We know the locusts laid eggs over a large area, though the

number that survived to lay eggs was not a large proportion of the original swarms. Actually, the swarms of 1904-05 were small, confined to a smaller area, and practically only in their normal habitat, the Goa and Kanara forests. How was it that the large number of locusts that were alive in June 1904 did not give rise to large swarms ? It is difficult to say ; we can accept the hypothesis that the climatic conditions of the large part of the area they spread over were not suited to egg laying and egg hatching. On the Western Ghâts and possibly in isolated parts of the Deccan, the rainfall was large enough to admit of (1) egg laying, (2) egg hatching, (3) the development of the young. Generally speaking, the rainfall was insufficient, and so far as experiments can guide us, insufficient especially for the development of the hoppers.

The writer's personal opinion is that a part of the hoppers died from lack of moisture. It was actually found possible to rear hoppers to maturity only in a very damp atmosphere. Such an atmosphere is normally found in the Ghâts, but not in many parts of the Deccan, Central Provinces and Central India, where the locusts spread to.

The monsoon of 1904 over a large part of Western India was light, and only in scattered places were the conditions suitable to the locusts. We may doubt if the conditions over a large part of the Deccan are ever suitable to locust hoppers in ordinary years, and we may perhaps look to this as the principle check on locusts. So soon as locusts become so abundant that they have to leave the Ghâts to breed, their increase is checked by the destruction of the young which hatch in unfavourable places.

This is at best a hypothesis, but one built on the available facts. There is no evidence that parasites or other checks accounted for the failure of the locusts to appear in vast numbers as they should have done in October 1904. The measures taken against hoppers were possible only in exceptionally wet localities from the very fact that hoppers were not found abundantly elsewhere.

In May 1905, locusts swarms again appeared in Belgaum and spread out from the Goa and Kanara forests into Dharwar,

Belgaum and Bellary. There were none in the Ghâts of Thana and Ratnagiri, and the locusts had apparently been reduced to their normal numbers and were behaving normally again. The occurrence of the locust plague over a large area would appear to depend upon the behaviour of the swarms of the Kanara and Goa forests. If these become large, spread over a large area and can breed successfully outside their normal breeding places, we may look for another locust year. But it would seem to require exceptional conditions and we may regard the size of the swarms of the Kanara and Goa forests as the indication that such a thing is likely to happen.

PART V.

THE BOMBAY LOCUST AND ALLIED INSECTS.

THE nomenclature and classification of Indian grasshoppers and locusts is in a backward condition, the actual scientific designation of various species not having been settled. Authorities on this group differ in the species to which they assign the Bombay locust. Specimens in the Indian Museum were assigned by Mr. de Saussure to *Acridium succinctum* L.; Mr. W. F. Kirby of the British Museum regarded specimens sent to him as being *Acridium rubescens* Walker. For the present, it is necessary only to have a scientific designation as accurate as our present knowledge will allow, and the name *Acridium succinctum* L. is taken as representing the best name available. *Acridium* is a genus closely allied to *Schistocerca*, and these two genera include the greater number of the true locusts. They form a part of the family *Acridiidæ*, or short-horned grasshoppers, of which some 120 species are named in the Indian Museum and at least one thousand species probably occur in India. Many species have been found in the course of this investigation, and only the commonest species of India can be said to be even named, far less known. The family *Acridiidæ* includes all those insects known as locusts, which term is frequently misused. A locust is an Acridiid, which multiplies to a large extent, forms swarms and migrates over large areas of land; a grasshopper is an Acridiid that does not form swarms which migrate. The essential thing in the locust is the migrating swarm; there is no structural difference, it is simply a matter of habits and life history. Restricting the term locust to its proper sphere there are in India two locusts at least; the North-West or

Migratory locust, *Acridium peregrinum* Oliv. and the Bombay or Western India locust, *Acridium succinctum*. L. There are doubtful locusts, and the main mass of Acridiids are grasshoppers pure and simple, without the swarming or migrating instinct.

In fact *Acridium succinctum* itself is a grasshopper pure and simple in most parts of India, where it occurs sparingly and not in sufficient numbers to form swarms.

In any year there are probably enough of the spotted grasshopper, or the rice grasshopper, or the painted grasshopper to make quite large swarms and do much damage were they all together in one place and moving about, but as they are scattered over India and stationary, their ravages create less notice. The immense swarms and the extraordinary movements of the Bombay locust give it an enormously exaggerated importance; it fills the imagination and appeals to the human mind. The damage done by the locusts is probably far less than that done yearly by two pests of cotton (*Earias fahia* and *E. insulana*) or by the mothborer in cane, and sorghum *chilo simplex*). In point of numbers the locusts are far below the probable numbers of these pests in any one year; in point of destruction and actual loss of crop, the ordinary pests are far ahead of the Bombay locust in its worst years.

The Bombay locust is readily confused with other species, especially as it may occur in the same place and at the same time in two or (during the coupling season) in three distinct colour forms. It is no easy matter to put down on paper the differences between closely allied species and practically impossible to do so in language understood by everyone. Distinctions based on the fact that the pigment in the wings is, or is not, situated in the wing substance are useless, as also is such a distinction as a streak of colour below the eye. The number of species with which the locust may be confused is, however, small if all considerations are taken into account. One may at once eliminate all species with a length of less than two inches and which are not at least $\frac{1}{2}$ inch across the body. This eliminates the greater number of the 120 known and the many

unidentified species of grasshoppers. Remembering that green never enters prominently into the colour of the locust, and that all uniformly coloured specimens, unless bright red, cannot be the Bombay locust, eliminates all but a very few species. Thus the migratory locust is often uniformly purple red, has fore wings spotted in small spots from base to apex, and has small indented lines round the neck. The large painted grasshopper (*Poecilocera picta*) is brilliant blue green and yellow; the hooded grasshopper (*Seratodus Monticolles*) is green; the very large *Acridium melanocorne* are uniformly dull red brown or brown in colour. All grasshoppers known in the Western and Central part of India can be eliminated on size and colour except one, the so-called spotted grasshopper, *Acridium æruginosum* Burm. This has the spotted wings, the stripes of colour, the same dimensions as the Bombay locust and is closely similar in appearance. Minute structural characters of the male and female external genital organs are quite valid evidence for the entomologist but cannot be clearly shown on paper. The spotted grasshopper is yet a very characteristic insect, coloured in dark brown and white, with wings conspicuously blotched with black and with a conspicuous white blotch at the side of the neck. It is more robust and strongly built, and never varies in colour. This is the insect most commonly confused with *Acridium succinctum*. Probably nothing but an actual comparison of specimens of both species would be sufficient to show the very characteristic but small differences in these two species. Specimens of the two should be kept side by side in every district office, and if the specimen is not *Acridium æruginosum* it is likely to be one of the many coloured varieties of *Acridium succinctum*; that is, if it is not eliminated by the characters given above. The following are the species that can be found readily and may be confused :—

Acridium peregrinum Oliv. (Pl. VIII, IX, fig. 2 and X, fig. 3.) The North-West or Migratory Locust. This entered South Gujarat from Kathiawar early in December 1903, and swept eastwards in swarms. It is liable to visit any parts of Central and

Northern India. It is uniformly reddish purple or yellow in colour. The forewings are spotted with small spots from base to apex. There are no lines of colour along the neck, or on the head ; there are indented lines (fine grooves) round the upper part of the neck. It is slightly smaller than the average female Bombay locust.

Acridium æruginosum. Burm. (Pl. VIII, IX, fig. 3, and X, fig. 5.) Common over Central and Southern India. Found in all stages at various times of the year. Probably never gregarious, and having no definite periods for reproduction. The large white blotch on the side of the neck, the conspicuous large black blotches on the wings, the general white and black colouring and more robust build easily distinguish it. Males are conspicuously smaller than females.

Acridium melanocorne. Serv. (Pl. XII, fig. 3) and similar species. The large solitary grasshoppers, uniformly red brown or brown in colour, larger than the Bombay locust, are easily marked from the locusts. They are not common but occur all over India.

Poecilocera picta. (Pl. XI, fig. 4.) The painted grasshopper, with stripes and lines of brilliant blue-green and yellow, common on the 'Ak' plant, Calotropis spp.

Teratodus monticollis. The hooded grasshopper ; a sharp hood rises over the body, in a semi-circle, being the immensely-produced prothorax. Green or dry grass colour. Very narrow across the body.

Demodocus robustus. (Pl. XII, fig. 1.) This and other species of *Demodocus* are to be recognized by a flattening of the neck, with two stripes of colour at each side of this flattening. On looking down at a Bombay locust in the dry grass-colouring, one sees one large stripe of yellow from head to wings. On looking at a Demodocus one sees two, curving from head to wings, with a flat dark space between. This is unmistakeable.

Hieroglyphus furcifer. Serv. (Pl. VIII, fig. 4, and Pl. X, figs. 7 and 8.) The rice grasshopper. Uniformly green or browny yellow in colour, with little black lines on the sides of the neck. Smaller than the locusts. This is the

familiar Pha-Pha of the Central Provinces, of Gujarat, Belgaum, Mysore and other parts of India. It occurs chiefly in rice land or other wet land and is very widely distributed in India. As this insect lives in its winged stage only from August to October, it is confused only with the first flying locusts.

Practically all other grasshoppers known to occur in Western India are eliminated by size. Many specimens and many species have been collected in the course of this enquiry, and the species of this group found in Western India are fairly well known. It is believed that except the above no other species is likely to be confused with this locust. The earlier stages of the various grasshoppers are not invariably distinguishable, and many varieties of grasshoppers, old and young, were sent in for identification.

One rule that should be borne in mind is that *every winged insect is full grown.* A grasshopper, however small, that has wings, cannot grow any more and cannot be the young of a larger insect. This rule is without exception, and one may instantly reject as locust hoppers all insects with wings. Beyond this, the subject becomes involved and complicated by the great number of hoppers which are found during the rains. As a rule these cannot be identified until they are reared to the perfect insect. In years to come, it may be possible to rear and study large numbers of hoppers and so be able to identify our common kinds. At present this is impossible and a few species only are accurately known in the hopper stage. One must remember that hoppers pass through at least five stages before becoming winged, and in each of these undergo changes of size and usually of colour. A description of a hopper in the first stage would not fit the same hopper in another. For instance, the hopper of the rice grasshopper emerges in June as a small dark insect with a light green stripe down the back. In the next stage it becomes green, and remains green for three stages. In the fifth stage it has the green rudiments of wings, and the black lines on the neck, with a tinge of reddish brown on the legs, the posterior half of the large leaping legs

blue. There are here three very distinct looking insects, all stages of one insect.

The young of the painted grasshopper (*Poecilocera picta*) is very different from the perfect insect, the ground colour yellow with stipples and fine lines of black and vermilion spots. Only in the last stage but one does the characteristic blue-green and yellow commence to appear. The young of the hooded grasshopper is green, with the conspicuous development of the hood already showing. The young of the spotted grasshopper is uniformly green (Pl. XI, figs. 1-3) with the posterior edge of the neck flesh colour. It is at once distinguished from the young of the Bombay locust.

As size is of no value as a criterion of the young Bombay locust, one cannot distinguish it from other hoppers. Descriptions of every stage are reproduced above; if one wishes to ascertain whether a certain hopper is that of the Bombay locust, measure the hopper, find the stage of the locust that is that size, and see if the description fits the hopper. Hoppers almost identical with those of the Bombay locust are common and would deceive all but an expert trained to discern small differences. It is advisable to place no reliance on the determination of hoppers but to send the specimens for accurate comparison with guaranteed specimens of the hoppers of the Bombay locust.

The chief distinction that marks *Acridium succinctum* is the curious life history. Most insects emerge in the winged state with mature reproductive organs, live a longer or shorter period in this stage and lay eggs. Many pass through the cold season and dry weather in a resting stage, the supply of food being sufficient only in the rains. Others reproduce at different periods of the year, one brood succeeding another as long as there is food. In the family *Acridiidæ*, some are many-brooded, reproduction taking place at different times of the year : some are apparently two-brooded, and this includes the migratory locust, *Acridium peregrinum*. The Bombay locust is one-brooded, as is the rice grasshopper and some others. For one-brooded insects, which find food for their

young during the rains, the long period from November to June has to be passed through, and the greater number of insects pass this in some resting stage; the rice grasshopper lays eggs in October which hatch when the first rains fall, and so lives eight months in the egg stage. The most striking fact in the Bombay locust is its habit of living eight months as a full-grown insect, waiting until the near approach of the rains before the reproductive system develops.

APPENDIX A.

THE ACTION TAKEN AGAINST LOCUSTS IN THE BOMBAY PRESIDENCY.

As already stated, the locusts appeared in large numbers and commenced to fly in October 1903. As they left the northern part of the Presidency and moved south, no measures could be taken against them in the fertile district of Gujarat and no action was taken by the Government.

In January, when the swarms were concentrated in the Ghâts south and east of Bombay, the locusts again attracted attention from the very evident damage done to the forests but no action was deemed necessary; in February the Superintendent of Mahableshwar reported that the station was being defoliated and that the locust swarms should be checked before the forests round the station were entirely stripped. Experiments were then made against the swarms but no action was taken on a large scale. The matter was, however, regarded more seriously as dissection of locusts showed developing ovaries, and three Assistant Collectors were put on special duty to watch the movements of locusts throughout the Presidency and to spread information among the people as to the locusts and as to any measures found available for destroying them. These officers remained on this duty until October.

During April and May, the question of locust destruction was taken up, and in different districts action taken immediately. Information was diffused as to the locusts, rewards

were paid for killed locusts and an effort was made to deal with swarms at night. The following district orders were issued in Kolaba District:—

DISTRICT ORDERS.

No. 2497, dated 6th May 1904.

In their Resolution No. 3268, dated 29th April 1904, Revenue Department, Government have directed that steps shall forthwith be taken to destroy adult flying locusts. Only a very short time now remains during which this can be done, and the work must therefore take precedence of all other work in any "saza" or village where locusts appear.

2. When a swarm of locusts is observed in the afternoon preparing to settle for the night, the villagers must at once send information to the talati, if there is no resident kulkarni. The talati (or kulkarni) will thereupon leave any other work he may have in hand, and proceed at once to the village, where he and the patel will require the people to turn out and destroy as many locusts as possible after they have settled at night and before they begin to fly in the morning. They may be killed by being knocked down with branches or cloths; or they may be caught alive, thrust alive into cloths or bags, and plunged into boiling water; or it may be found possible to apply lighted torches on the ends of long bamboos to the branches on which the locusts have settled, thus singeing their wings and either killing or crippling them.

3. In the morning, when the locusts begin to move and it is no longer possible to approach them without disturbing them, the dead locusts should be collected and weighed. They are to be paid for at the rate of ½ anna per seer of locusts. The talati (or kulkarni) will make out a list showing the amount of reward due to each person (or to the villagers collectively, if that method of payment should appear expedient) and send it to the Circle Inspector, who will at once disburse the amount from his permanent advance. Similar procedure should be adopted to pay for cost of oil for torches, &c.

4. Circle Inspectors must keep their permanent advances constantly recouped, and apply for a temporary increase of advance if this is found necessary. They must arrange to obtain prompt information of the appearance of swarms in their Circles, and to visit at once the affected spots, discontinuing all other work for the time. They will afford the talatis all possible assistance, will impress on the people the Commissioner's orders that no remission for damage by locusts will be given where the people do not make strenuous efforts to destroy them, and will note for future guidance those villages where the people are backward in this matter.

5. Sub-divisional Officers, Mamlatdars and Mahalkaris will further the work to the best of their ability. They can disregard all routine inspection work for the rest of the season.
6. Operations within forest limits will be ordinarily undertaken by the Forest Staff ; but the people must be made to understand that they must turn out to render assistance whenever called upon by the Forest Officers of whatever grade.
7. So much for what can be at once done with respect to adult locusts. As to organisation for further action, the Sub-divisional Officers should now submit at once the reports called for in this Office No. 1976, dated 13th April 1904.
8. The Assistant Collectors, who have been placed on special duty, will be visiting the affected taluks. Their orders must be regarded as having the same authority as those of District Officers ; and subordinates of all Departments must, when on tour, take every opportunity of impressing on the villagers the instructions given by those Assistant Collectors in the matter of locust destruction.
9. Special reports should be made by Mamlatdars and Mahalkaris to the Assistant Collectors on special duty ; also to this office, when the locusts are observed to be beginning to copulate : and a reward of rupee one may be offered for the first correct information of the discovery of locusts eggs within the limits of a village.

This work continued in various parts of the Presidency under the advice of the special officers on locust duty or of the District officials. The following instructions were issued by Mr. T. R. Bell, Assistant Collector, on locust duty :—

Copy of detailed instructions as to the methods of destroying flying locusts, prepared by Mr. Bell.

The only time during which the work can be carried on is at night. The locusts begin to settle down in the evening and after a time become torpid, unless the night is very warm. The best time to begin the work is at 2 A.M. and it should be continued till sunrise or so long as the locusts do not fly away.

The methods of killing depend a great deal on circumstances. The details given below will, however, be a guide.

As a rule the locusts will have settled on trees for the night. If these trees are fairly large with even ground underneath, devoid of shrubs, the best way is to use a gang of men as follows :—A gang should consist of 20—25 men and women under an overseer, and several gangs may operate on the same swarm. Each gang should be in three sections of seven or eight men and women each. One man will climb the trees and shake the branches with great force when the locusts will fall down, or he may use a long pole with a hook at the

end and shake the branches with the pole. Another man must be provided with a torch of some kind to give light. The other five or six men and women will beat the locusts which fall down to the ground with brooms and stampers of wood. Women use the brooms better than men. Generally also the brooms are more effective and there should be at least three or four brooms in each section of beaters. Each overseer will have three gangs like this and he should take care to keep them working regularly forward in a straight line. Other beaters should take the same precaution. The work will go on all right from 2 A.M. or 3 A.M. until sunrise and by this time a considerable area of jungle will have been covered.

In the morning a large number of locusts will be found dead on the ground and the beaters should now start where they began work and collect these in bags. But a great number of locusts will only be stunned by the beating of brooms, and when morning comes they will be seen to have climbed up small shrubs and plants and up the lower parts of the trunks. These should be collected by hand at the same time and placed in bags. This is most important as the larger portion of the locusts will be killed in this way. When a bag is nearly filled, it should be plunged for some minutes in a pot of boiling water—which has previously been put in a suitable place—and when the locusts appear to be dead, the bags should be emptied out and the work begun again. This work should be continued till the locusts begin to fly away.

It will sometimes be better to get a fresh gang of workers to gather the locusts in the morning, as the men and women who have been working during the night lack energy in the morning, and the gathering of the stunned locusts is important.

After the work is finished the locusts can be weighed and the rewards paid.

It is much more effective for a gang to work under a good supervisor. The reward will then be distributed among all equally. Many more locusts will be killed and more money earned in this way than if each rayat worked for himself. It may sometimes be cheaper to pay each man a fixed sum for the night instead of paying a reward according to scale, but as a rule payment by results is best.

Instead of beating the locusts that have fallen down, it is sometimes a good plan to sweep them into heaps and have them crushed with stampers, or they may be swept in this way into a bag. This can only be done where the ground is fairly flat.

If the ground is rough and uneven and also where there are many shrubs, stampers are of no use and only brooms should be used.

Brooms can be made of thin bamboos. The part of the broom used for sweeping should be broad and flat so as to give a large striking surface. Small branches and twigs of trees make good brooms. The leaves and small twigs soon get knocked off, but if two or three leafless brooms are tied together, an excellent beating broom will be formed.

Where the trees are low and the ground uneven or covered with shrubs, beating will not be practicable. The trees should be shaken as before and the locusts that fall down should be gathered by hand and placed in bags. The locusts are then killed by plunging into boiling water.

If the ground is covered with low shrubs on which the locusts are settled, they can be collected in handfuls off the shrubs and put into bags.

Sometimes a large isolated tree is covered with locusts. It is then a good plan to hold cloths underneath the tree. When the tree is shaken, the locusts fall into the cloth, when they can be easily crushed.

A great deal depends on good organization. A well-organized party of 25 beaters is more effective than disorganized beaters. Experience has shown that the best way is to pay the beaters according to results.

During June the locusts started egg laying, and preparations were made for collecting eggs and destroying hoppers. Rewards were paid for coupling locusts, for eggs, and later for hoppers. The rate for locusts during the coupling season was raised from half an anna to four annas per seer, and Rs. 10 was offered for the first information of egg laying in each village.

On the whole few eggs were found, but a fair number of locusts were captured by hand during the coupling period and probably as much good was done at this time as at any period. By the first July, egg laying was stopping on the Ghâts and the next step was to destroy hoppers. The sum total of locusts destroyed in the Northern Division of the Presidency is put down as 52,000 seers (less than 1,000 cwts.), in the Director of Agriculture's letter dated the 14th July. In a later letter, the weight of eggs destroyed in two parts of Kolaba District is put down at thirty-seven and a half maunds (over 24 cwts.), but this is the only record of extensive egg destruction. The destruction of hoppers was then undertaken partly according to the method described, partly in other ways. Rewards were paid for hoppers and it was found that very many insects which were not hoppers were included. The rates for small hoppers varied and an endeavour was made to pay so that each man could earn a fair day's wage. As much as two rupees per seer for small hoppers was paid but this was steadily reduced as the hoppers grew bigger.

The following extracts are of interest as giving glimpses of the action generally taken throughout the infested localities :—

Letter from the Director of Land Records and Agriculture, No. A.—4189, *dated 14th July* 1904.

"5. The reports regarding the several districts are summarised below :—

Gujarat	Free, except the Panch Mahals where locusts are said to have deposited eggs in several localities. (It may be noted that last year also locusts bred in the grass lands in the Panch Mahals.)
Khandesh	Widely but sparsely infested, the locusts being in a somewhat backward stage.
Nasik, Poona and Satara	Western portion seriously infested.
Nagar	Practically free.
Thana and Kolaba ..	Hilly talukas seriously infested.
Ratnagiri	Northern part infested. Southern part practically free.
Sholapur	Practically free.
Bijapore	Reported to be free.
Dharwar	
Belgaum	
Kanara	
Kolhapur	

"7. In the Northern Division 52,000 seers of locusts are reported to have been destroyed in all, of which in two weeks 10,000 seers were destroyed in the Mokhada Peta, where the Mahalkari is reported to have organised operations with vigour and intelligence."

Letter from the Director of Land Records and Agriculture, No. C.—322, *dated 6th August* 1904.

"In continuation of my letter: No. A.—4189, dated 14th July 1904, I have the honour to submit a further report regarding locusts.

"2. Except in the Khandesh District adult locusts appear to have now ceased to exist. During the week ending 16th July, nearly 10,000 seers of adult locusts were destroyed in the Northern tract, of which more than two-thirds were destroyed in Khandesh.

"In this district the hill-tribes having lost their nagli took to egg collection with vigour, and the conditions being favourable, 37½ maunds of eggs have been destroyed. On Mr. Lefroy's estimate of 100,000 eggs to a seer, 150 millions have thus been destroyed at a cost of Rs. 1,354."

Letter from the Director of Land Records and Agriculture, No. A.—5902, *dated 26th September* 1904.

"In continuation of my letter No. C.—322, dated 6th August 1904, I have the honour to submit a further report regarding locusts.

"2. Locusts' eggs ceased to be found after the middle of August. The only tract where measures for their collection met with any success was in Northern Kolaba where over 80 maunds were destroyed.

"3. The area infested by hoppers includes nearly the whole line of the Ghâts from Sangameshvar northwards, with the country adjoining on the east and west. Hoppers are also found in considerable numbers over most of the Khandesh District.

"The hoppers are not increasing in size as rapidly as might have been expected. Individuals are as a rule under an inch in length and give no indication of being ready for flight soon. They have not yet caused any serious damage to the standing crops, but in places it appears that they are now attacking the leaves and soft unripe grain of various crops.

"4. Measures for the destruction of the hoppers were in full operation by the middle of August. As the hoppers do not develop the gregarious instinct until after they assume their wings, it has been found impossible to drive them in a special direction. Unlike the locust of North-Western India they cannot therefore be dealt with on an easily organised plan. The only method of dealing with them, which has met with any success, is to catch them in large bags which are dragged over the ground. The method is slow and difficult.

"By the 3rd of September, 193 maunds of hoppers had been destroyed in the northern tract, of which four-fifths were destroyed in the Thana District. Up to the same date 85 maunds had been destroyed in the central tract. The ordinary cultivator shows no inclination to take part in the work of destruction which has been chiefly carried on by the wild tribes and low castes for the sake of the rewards."

Letter from the Collector of Poona, No. 9855, *dated* 30*th September* 1904.

"In continuation of this office letter No. 9537, dated 22nd instant, asking for a further grant of Rs. 7,500 for the destruction of the locust hoppers, which was sanctioned under the Secretary to Government's memorandum No. P.—318 of 28th instant, I have the honour to report that the killing of locust hoppers is now progressing vigorously throughout the west of the district, and I am receiving large indents for money from the Mamlatdars of Haveli, Khed, Junnar and Maval. These have practically exhausted the last allotment of Rs. 7,500 and it is now necessary that further funds should be provided.

"2. The supply of hoppers being very large and the energy of the people, now that weeding and transplantation operations are over, having been readily diverted to locust catching as a means of earning money, it seems to me highly probable that the sums payable as rewards will continue for some weeks longer to be very considerable.

"3. I have reduced the rate payable for hoppers from Re. 1 per seer to annas 8 per seer, with effect from to-morrow, October 1, but even at this rate, which is at present perfectly reasonable, I anticipate a heavy demand."

Letter from the Collector of Satara, No. 7511, *dated* 1*st October* 1904.—

"2. The previous allotment of Rs. 4,000 has been almost spent. Hopper locusts are now found in the three talukas of Javli, Satara and Patan, and in the Shirala Petha. They are found in very large numbers in the forest villages in the Koyana and Salshi villages of Javli. The amount now asked for will not be spent unless it is found to be actually required, but there is every probability that it will be needed, as several of the officers conducting the operations are applying for fresh allotments, and I have had to raise the price of a seer to secure labour."

Letter from the Collector of Ahmednagar, No. B.—4814, *dated 6th October* 1904.

"I have the honour to inform you that the sum of Rs. 3,000 placed at my disposal for the destruction of locusts in this district, as per paragraph 1 of Government Resolution No. 3268, dated 29th April 1904, Revenue Department, is nearly exhausted. The work of killing locust hoppers is at present in full swing in the Akola Taluka. I have therefore the honour to request that you will be so good as to move Government to sanction by wire an additional allotment of Rs. 2,000 to this district."

Letter from the Collector of Ratnagiri, No. 4095, *dated* 4*th October* 1904.

"3. Mr. Mackie writes as follows:—

'The method of catching hoppers by hand is now in general use, and from experiments which I have had made in Khed appears to be more effective than any other.

'A very appreciable diminution in the number is now discernible. In my last report I referred to this in regard to several villages in Khed. Round about Palgad in Dapoli Taluka, I have personally inspected several villages formerly much infested, and find that the hoppers have now grown quite scarce comparatively. The present campaign, I think, we may say, is proving successful.

'At the same time, the Mamlatdar of Khed reports that hoppers are beginning to fly in some cases. This ought not to be—they ought to have been killed off—and I have issued instructions in accordance with your No. S. R.—101, dated 20th September 1904, that all fields which have not been properly cleared should be carefully noted. I have also authorised the employment of day labourers on a guaranteed minimum wage in order that labour may be employed in the places where it is most needed. So long as the reward earned exceeds the wages, the reward is paid. Otherwise the promised wages are paid, but when once this latter has been found necessary, the question whether it is necessary to continue day labour is to be considered. No such case has arisen yet. In Dapoli men can be engaged freely at two annas per day.

'Mahars, Kunbis, and Katkaris compose the great bulk of the people employed in destroying the hoppers.'

Letter from the acting Collector of Ratnagiri, dated 11th September 1904.

3. But in a great measure the need for employing paid labourers has itself diminished as the rate of reward now given has given a great impetus to the work, and in every affected area large quantities are daily destroyed and brought up for reward. Payments are made at several centres* in each taluka besides the taluka or Mahal stations, by the charge Superintendents or by local committees consisting of the schoolmaster, Khot, Police Officer, Police Patel and such other respectable persons available on the spot. These committees are working very satisfactorily. It is indeed due to the multiplication of payment stations that the work of catching locusts hoppers has now been taken up in earnest by the labouring classes, as formerly owing to the long distances people had to go for payment, they did not care to exert themselves even when the rate was increased.

* 5 in Sangameshvar.
6 in Chiplun.
7 in Khed.

4. The allotments (Rs. 11,000) made by Government have all been expended and I have had to wire to the Chief Secretary to Government for an additional allotment of 8,000 rupees.

5. As to the present rate, 1 rupee per seer (2 lb.), all my assistants recommend that it should be continued for the present and from my observations I agree with them. Now that their number is getting reduced, it is increasingly difficult to get at the hoppers in the crops. And then their growth is fortunately slow. Several experiments made here to-day with hoppers from different parts of the taluka gave the following results (approximate) :—

Minimum number per seer (2 lb.)	...	...	...	2,000
Maximum number per seer (2 lb.)	...	...	...	3,900

On this point Mr. Mackie writes as follows in his report dated 8th instant:—

"2. No doubt in some few villages a man might make four or five annas a day but I have made several experiments and personally inspected the state of things in several villages which may be regarded as average and there I find that the present rate is not excessive. A man by hard work can only make two or three annas a day.

" 3. One of these experiments has just been completed. Two men working a dhotar caught 17 tolas in five hours. I noticed that some of the hoppers had wings reaching to the tip of the tail and this morning in another village I found they were growing so big as to be able quickly to get over the top of the screen I was employing. In view of these facts nothing that would in any way cause relaxation of the efforts at present being made should be done.

" 4. The Mamlatdars are of like opinion. In most parts of Depoli in fact the Mamlatdar reports the present rate does not adequately reward the exertions necessary.

"6. The standing crops have not so far been much damaged by hoppers, but owing to the destruction of seedlings by locusts in the commencement of the rains, considerable areas (chiefly nagli) have remained unsown. Inquiry about these is proceeding with a view to ascertain whether suspensions or remissions will be necessary.

Letter from the Collector of Kolaba, No. 7116, *dated* 22*nd October* 1904 :—

" In continuation of this office No. 7000, dated 17th instant, I have the honour to inform you that since writing that letter I have had considerable demands for funds for destruction of locusts from most talukas, but more particularly from Karjat.

" 2. In this taluka I have now reduced the rate of reward to four annas per seer of hoppers, and I do not think that the lowering of the rate will reduce the number brought in as the hoppers are growing rapidly. I shall shortly lower the rate similarly in other talukas.

" 3. I have now gone carefully into the figures and I think that a further allotment of Rs. 4,000 in addition to that asked for in this office number above quoted will probably meet all requirements up to the time of completion of the reaping of the crops, after which I hope it will be possible to suspend operations.

" 4. I therefore request the favour of Government sanctioning an allotment of Rs. 6,000 in all, *i.e.*, Rs. 4,000 in addition to that already asked for and not yet sanctioned.

" 5. The reason for the differentiation between Karjat and other talukas is as follows :—

" On taking charge of the district on 1st instant I found a note from my predecessor, Mr. Bonus, to the effect that in his opinion the then existing rate of eight annas per seer might shortly be lowered to six annas. I issued orders on 14th to lower the rate to that extent and had scarcely done so when I received a report from the Mamlatdar of Karjat recommending a further reduction to four annas for that taluka and stating that such a reduction was not likely to prejudicially affect the rate of destruction. I reduced the rate for Karjat accordingly to four annas and am now awaiting reports from the Divisional Officers whether a similar reduction can now be made in other talukas without interfering with the work.

" 6. It has just been reported to me that locusts hoppers killed in Mahad are being taken into the Khed Taluka of the Ratnagiri District owing to the present rate of reward there being higher. As it is obviously desirable that the rate of reward should be the same in adjoining talukas of different districts, I have informed the Collectors of Thana, Poona and Ratnagiri of the rates prevailing on their borders in this district and shall inform them of any alteration in those rates. I have requested them to reciprocate the information."

Letter from the Cllector of Ratnagiri, No. S.N.—121, *dated* 13*th October* 1904 :—

"In reply to your No. s.r.—94 of 12th instant, inquiring how long expenditure on locusts will continue, I have the honour to refer you to my weekly report No. 4095,* dated 4th instant. As I have already reported, hoppers in the early stages of growth are still found almost everywhere and but few full-grown ones are met with, testifying to the undoubted success of the operations so far. It seems to me, therefore, that the destruction of hoppers must continue until they are all disposed of, or at any rate until all standing crops have been reaped. I estimate that this will not be before at least three weeks more and probably four. Of course it would be disastrous to suspend the operations at this stage although the amount paid as rewards may have exceeded any anticipations. It would be equally disappointing should swarms of locusts arrive from above the Ghâts and destroy what has been successfully saved so far. Within this week there have been persistent rumours that locusts have arrived in that tract, and I have asked the Political Agents, Kolhápur and Sávantvádi, to inform me should it be so. I have no information either as to whether similar measures for the destruction of hoppers are in progress in the Native States above the Ghâts. I mention this as I have heard that in at least one State, *viz.*, Bávda, bordering on the Rájápur Táluka, nothing is being done although there are hoppers there. I must say, however, I have not been able to verify this information."

Letter from the Director of Land Records and Agriculture No. c.—651, *dated* 28*th October* 1904 :—

" In some tálukas of Thána, the locusts have already begun to fly, and the Collector of Ahmednagar informs me that swarms are reported to have migrated from Thána into the Akola Tàluka.

" 5. It appears that when the weeding and transplanting operations were over, the liberal rates of reward sanctioned succeeded in inducing the cultivators to undertake the destruction of hoppers with a considerable amount of energy.

" It is not, in my opinion, possible to judge of the effect that this destruction has had upon the plague, until some information is obtained as to the numbers and extent of the winged swarms.

" 6. But even if it be found that the numbers destroyed bear an inappreciable proportion to the numbers which have survived, a benefit of considerable importance will have been secured by the grant of the rewards, for the cultivators, who have received them, are probably the men who will suffer most severely from the depredations of the locusts, and the payments made to them may be regarded as a measure of State relief.

"7. It is, I think, desirable that a record should be kept of the movements of the winged swarms, for last year little attention was paid to them at this stage of their development: and their life history is still incomplete. I have the honour, therefore, to suggest that all Collectors be requested to forward a weekly report of the areas in which locusts swarms are observed, of the general direction of their movements and of the damage which they effect, to Mr. Knight at Poona.

Summary of Táluka reports showing the progress made in the destruction of hoppers.

Name of district and táluka or petha.	For week ending 16th October 1904.		Total.		Remarks.
	Weight of hoppers destroyed.	Amount paid as reward.	Weight of hoppers destroyed.	Amount paid as reward.	
Poona.	Mds.	Rs.	Mds.	Rs.	
Mával ...	28	562	34	690	Hoppers have now reached the final stage and will soon begin to fly. Damage so far slight, though the hoppers have commenced to eat ears of corn and leaves in some places.
Haveli ...	100	2,000	450	14,650	Every week about 100 maunds destroyed. Hoppers still in their infancy, hence no damage to crops.
Mulshi Petha ...	28	567	55	1,294	Hoppers about 1½ inches in length and destroying nágli and wari crops.
Khed ...	120	3,823	220	7,430	Hoppers destroyed by poor cultivators and low caste people in Mávli villages in large numbers. Damage to sava and nágli. Rice crops also attacked but safe so far.
Junnar ...	13	260	55	1,605	Hoppers have reached the stage of young locusts though not yet able to fly, and eating grass and leaves of young crops. Damage so far insignificant.
	289		814		
Násik.					
Kalvan ...	½	4	1½	14	Slight damage reported from 2 villages on the borders of Surgána and the Dángs.
Igatpuri ...	2¾	27	2¾	27	
Peint ...	31	197	94	558	Insects still in the hopper stage. Damage so far not appreciable except that in some fields leaves of nágli have been eaten. 60 villages in the táluka infested.
Kolába.					
Roha ...	⅞	17	10	280	Kulkarnis mostly engaged in the work of destruction. Hoppers doing damage to rice crops in the Kolad Circle.
Pen ...	9	175	40	895	Hoppers now grown in size. Some of them reported to be bigger than the adult locusts that appeared last year. Hoppers now met with on crops only.
Mahad ...	18	369	152	2,535	Extent of damage cannot be ascertained at present.
Khálápur ...	7	135	18	416	Hoppers fully developed, though not strong enough to fly. Their colour turning brown. No damage to standing crops.
Mángaon ...	9	81	177	2,069	No damage to crops.
Panvel ..	...	...	3	90	Only 3½ seers of hoppers destroyed during the week ending 16th October 1904 and Rs. 1-12-0 given as rewards
	44		400		

"8. When the locusts have emerged into the winged stage, I would recommend that the reward be reduced to the rate in force in the spring of half an anna per seer.

"9. I have the honour to suggest that special attention should be given to observing their habitat during the winter. It is surmised that at this period last year they took refuge in the forests of Kánara, but no certain information is available. It is possible that the cold of these months may render them so torpid that if they are congregated in any accessible locality, effective measures may be devised for their destruction on a large scale."

Letter from the Collector of Thána, No. 12321, *dated* 15*th November* 1904 :—

"With reference to Government Resolution No. 7299 of the 26th September 1904, I have the honour to report as follows :

"2. Government up to date sanctioned a total allotment of Rs. 18,000 for this district for the destruction of locusts. Out of this allotment a total expenditure of Rs. 16,572-12-7 has been incurred up to the week ending 29th October 1904, of which Rs. 14,834-1-9 were spent in rewards, Rs. 1,721-10-4 in purchasing *zolis* for catching locusts and Rs. 17-0-6 in miscellaneous expenditure. There is thus now a balance of Rs. 1,427-3-5 available for expenditure.

"3. The results achieved with this money are that 7 seers of eggs, 589 maunds 38 seers and 74 tolas of locusts and 1,229 maunds 7 seers and 464 tolas of hoppers were destroyed.

"4. Measures are still being taken in Murbád Táluka and Mokháda Petha. In other tálukas the hoppers have either totally disappeared or have become so large that they can now no longer be caught.

"5. Apart from some slight damage to seedlings, which was largely repaired by fresh sowing, the early crops have escaped, and as far as can be judged, the late crops will also be safe, with the possible exception of tur, peas and the like in the ghât tract.

"6. The people were at first sceptical and apathetic, but the personal stimulus of officers and the prompt payment of rewards at a reasonable but not excessive rate roused them to the work of destruction which was steadily kept up with all the interruptions of their ordinary work in the fields ; and the well to-do classes have helped with subscriptions for locust bags to the extent of Rs. 1,325, so that altogether the credit of the work, such as it is, must be given to all for seconding the efforts initiated by Government, which I believe are cordially appreciated in the district."

In October 1904 the locusts were winged and hopper destruction ceased. Winged locusts appeared in swarms in various places but evidently the bulk of the insects had been killed and there was no fear of the enormous swarms that emerged in 1903.

The swarms that did emerge in 1904 did little damage and passed into the forest regions. The following summary of the final reports is of interest :—

Summary of the reports of operations against hoppers.

DISTRICTS.	FOR THE WEEK OF THE REPORT.					TOTAL.		REMARKS.
	Number of talukas affected.	Number of villages affected.	Rate of reward.	Weight of hoppers destroyed.	Amount paid as reward.	Weight of hoppers destroyed.	Amount paid as reward.	
			As.	Seers.	Rs. a. p.	Mds.	Rs.	
Poona ...	2	14	4	3,164	*157 15 0	4,343	51,850	*Figures for Ambegaon Petha not reported. Report for week ending 17th December 1904. Subsequent report is blank as the locusts have disappeared from the district.
Ratnágiri ...	...	796	½	5,064	610 4 3	4,551	1,10,795	Report for the period from 20th November 1904 to the 30th idem. Payments of rewards stopped in the district from 1st December 1904.
Násik ...	1	3	2	1¼	0 3 0	237	1,284	Report for the week ending 13th December 1904. Subsequent report is blank as the locusts have almost disappeared from the district.
Kolába ...	1	1	½	11	0 5 6	527	10,911	Report for week ending 10th December 1904. Subsequent report is blank.
Ahmednagar	1	43	1	38	2 6 0	305	5,164	Report for week ending 26th November 1904. Further operations now stopped.
Thána ...	1	2	2	4	0 8 0	1,838	14,924	Report for week ending 26th November 1904. Subsequent report is blank as the locusts have disappeared from the district.
Sátára ...	2	26	2 to 6	2,400	472 0 0	1,450	5,636	Report for week ending 19th November 1904. Operations against hoppers closed.
Khándesh ...	1	4	4	35½	8 14 0	1	10	Report for week ending 19th November 1904. Figures for Taloda Táluka only.
Total ..	9	889	...	10,718	1,252 7 9	13,252	2,00,574	

Summing up the campaign against the locusts in the Bombay Presidency, it is evident that a determined effort was made to cope with the pest and that the excellent organisation that extends to every village in the Presidency was effectual in producing a very general action on the part of the people; that this should be so is remarkable in view of the intense apathy of the ryot, his objection to taking life and his disinclination to countenance anything new. The work was done by special castes, under the stimulus of rewards, but nothing would have been done had not the Government roused the general mass of the people to the necessity of action and the possibility of effecting something. The total destroyed is estimated by Mr. Knight as follows:—

4,152 maunds of adults equivalent to 66,432,000 individuals were destroyed or two-tenths of a per cent. of the estimated number.

One hundred maunds of eggs were destroyed representing 400,000,000 individuals, and 13,252 maunds of hoppers which at 1,000 per seer is 530,000,000, or a total of the young of 930 millions.

This number may be a very small proportion of the estimated total, but it is probably a very large proportion of what would have emerged in October had nothing been done. Especially so is this true of hoppers. Nearly every hopper that hatches probably becomes a locust, whereas probably not one locust in ten of those alive in the previous December lives to June and not more than one egg in two that is laid hatches. Hoppers killed are by far the most valuable item, and I think the estimate given of 1,000 hoppers per seer is far too low; a safe estimate is probably 2,000 per seer. Taking the average of all ages and size killed during the season and if we allow that 1,000,000,000 more would have emerged as locusts, that were killed as hoppers, we have a total of fifty large swarms destroyed by this one means alone. Fifty large swarms means a number similar to that which came out of Gujrat in 1903 and the money spent is well spent in preventing another year like that. It is impossible here to deal with the measures adopted

in every district or to discuss the whole question. Voluminous papers are available as to the action taken and the extracts given above serve to give an idea of what was done. The total sum spent in rewards by the Bombay Government amounted to a little over two lakhs. As stated previously, this money was not only used to destroy locusts and prevent a fresh attack, but *was a form of State relief paid to those who suffered from the presence of locusts.*

In all some 1,500 millions were probably accounted for, including adults, eggs and hoppers; of these 66 millions were adults which would have laid eggs and would have been responsible for another 3,000 million hoppers had they lived.

Allowing for all chances, for weather (which was suitable on the whole in Bombay, though not elsewhere), enemies, birds, &c., there can be no doubt that the money was very well spent, in averting the occurrence of another serious locust year.

GOA.

The following report is extracted from the information published by the Government of Bombay:—

Letter to His Excellency the Governor-General of Portuguese India, No. 6568, *dated* 25*th October* 1904:—

"As information has been received by me that locust hoppers have made their appearance in Goa, I have the honour to address Your Excellency on the subject, and to suggest that should inquiry prove that the report is true, measures may be adopted for their destruction similar to those that are in progress in British territory.

"2. The accompanying Resolutions that I have the honour to forward describe the life history of locusts and hoppers and the methods employed for their destruction. Officers of all Departments have been directed to place their subordinates under the orders of Collectors for supervising the operations. Rewards have been offered for locusts and hoppers destroyed at rates varying from eight annas to one rupee per seer, the rates being fixed so as to give the labourers employed a sufficient daily wage. Finally, proclamations have been issued warning ryots who fail to co-operate in the work that they will not receive remissions on land revenue on account of damage that may be done to their crops by locusts. The result of the operations is that several hundreds of

Government Resolution	No.	2912,	dated 16th April 1904.
"	"	3843,	" 21st May 1904.
"	"	5023.	" 1st July 1904.
"	"	5182,	" 7th July 1904.
"	"	5297,	" 12th July 1904.
"	"	5587,	" 21st July 1904.
"	"	6176,	" 13th August 1904.
"	"	6433,	" 22nd August 1904.
"	"	6765,	" 5th September 1904.

maunds of hoppers have been destroyed in this Presidency, and the numbers now to be seen are reported to have sensibly diminished.

"3. I beg to point out the danger to Portuguese as well as to British territory that will result if the locusts are not reduced in numbers by systematic and organized measures while they are still in the hopper stage."

Letter from His Excellency the Governor-General of Portuguese India, No. 100, *dated* 11*th November* 1904 :—

"I have the honour to acknowledge with thanks Your Excellency's letter No. 6568, dated the 25th ultimo, with copies of Resolutions regarding locusts.

"This Government have also taken some measures in the matter under the Notification No. 34, dated 3rd February last, a copy of which herewith enclosed, giving some instructions to the chief authorities of the district for the strict fulfilment of the provisions to be adopted, and to take energetic measures with the view of destroying the locusts wherever they make their appearance.

"A copy is also forwarded herewith of the report regarding the last invasion of acridiæ, which was forwarded to His Britannic Majesty's Consul at Mormugao, who had asked for it in order to comply with the request of Mr. W. S. Owen on special duty regarding locusts in the District of Kánara. In that report, as result of the observations made, it has been found that the insects do not lay eggs in Goa. However, it is certain that among the acridiæ, which about a week ago have made their appearance in several places of this territory, some young hoppers are seen, which fact leads to the supposition that some eggs were laid here though it has not been possible to verify positively."

NOTES ON THE LATEST INVASION OF THE PORTUGUESE TERRITORY OF GOA BY LOCUST.

I

History of the invasion.

Principal characteristics of the invasion.

1. The invasion of the Portuguese territory of Goa by locusts is chiefly characterised by the *non-permanence* of those insects in this territory; swarms more or less numerous crossed into Goa, generally not staying more than two months, disappearing completely, and re-appearing some time after in the same year.

Epochs of the partial invasions in a year.

2. Considering the period of one year, the first invasion takes place after the copious rains of the south-west monsoon, *i.e.*, during the months of September, October and November; in January or in the beginning of February fresh invasion takes place, which generally lasts till the end of March, and another invasion,

weakest of all, takes place in May. During the rainy season, between June and the middle of September, locusts have not been seen in Goa.

The intermittent invasions considered as a single invasion.

3. Although the invasion is characterised by the non-permanence of the locusts in our territory, it should be considered as a single invasion which lasted during the months referred to in paragraph 2 from September 1901 to May 1904.

Annual invasions' history.

4. For purposes of the history of the annual invasions the month of September should be taken as the starting point. In September 1901 locusts were seen in large swarms in the District of Satary destroying the hill crops to a great extent; they stayed in the hilly ground at the foot of ghâts, only an insignificant portion descending south and advancing westward; they remained there a short time and returned to British territory. It may be said that during the remainder of 1901 and a part of 1902 up to September the locust plague did not re-appear.

History of the invasion of 1902-3.

5. In September 1902 a similar invasion took place chiefly in Satary, but extending also towards the east of the Portuguese territory, being notorious on account of the swarms that swept down to the lowlands, causing terrible damage to the cocoanut and betel-nut plantations and also to the mango plantations and rice crops (vangana) which were ready for harvesting. This invasion of our territory lasted till the beginning of April 1903. The same year there was a fresh invasion in May, but in insignificant numbers. The migrations of 1902-03 as a whole cannot be classified as a public calamity; the damage to the crops was considerable, but it was not much felt except by such of the inhabitants of Goa as at the foot of the ghâts exclusively subsist on hill crops.

History of the invasion of 1903-4.

6. The invasion of 1903-4 from the very first was of exceptional violence. In September 1903 it localised at Satary and Embarbacem; it completely destroyed the crops on the high ground cultivated during the rains; and further strengthened by fresh arrivals of enormous numbers of acridiæ from the neighbouring territory. it extended to the lowlands of the said provinces and of Pernem and Sanguem, devastating the cocoanut and betel-nut plantations and but slightly damaging the rice crops which had been to a great extent already harvested.

About the end of December 1903 the locusts disappeared suddenly and completely from the Goa territory, when it was very much feared they would wend their way towards the more intensely cultivated portions along the sea-board. There is no plausible reason for the disappearance. The prevailing wind was north-easterly which should have rather helped them on. The only cause that might account for the sudden retreat of the insects is the rapid fall of temperature and the consequent increase of dews in the locust-infested area. About the end of January 1904 the invasion was repeated, increasing with extraordinary violence hitherto not heard of in this part of the country during the first

half of February. Clouds over clouds of locusts of great length, breadth and thickness flew in all directions over our territory, having entered it from the north-east and from various points on the eastern frontiers. During the passage they destroyed cocoanut, cashew, mango and betel-nut trees, injuring also almost all other trees, but luckily sparing the rice crops (vangana) sown in flooded fields. The heavy columns of locusts generally entered the Portuguese territory through the passes in the ghâts, and after making good their footing here, although extending over vast regions, it was found they had a tendency to move westward, sometimes flying very high and at others close to the ground, generally along the valleys avoiding the wind which had then commenced to blow from the sea. Early in February the nights being moonlit, the locusts did not rest, but proceeded on their onward course availing themselves of the hill, so that cocoanut plantations that were in splendid condition overnight were completely denuded of their leaves by the following morning. It was these nocturnal devastating raids that struck terror into the inhabitants of Goa. The raids which were recommenced and continued during the whole months of February and March and early part of April 1904 with more or less intensity, became a public calamity in consequence of a great destruction of the cocoanut, betel-nut and cashew plantations of Satary, Embarbacem, Panda, Astragar, Sanguelim, Parnem and Canacona and although they extended further west they did not cause grievous damage in the *Velhas Conquistos*. In the first fortnight of April 1904 the locusts vanished away from the Goa territory, but they returned in smaller numbers in the course of the month of May, vanishing again altogether before the commencement of monsoon, from which date they have not turned up.

History of the invasions as a whole from 1901 to 1904.

7. The locust invasion as a whole from September 1901 to May 1904, besides the peculiarity of non-permanence noticed in paragraph 1, presents two other points worth mentioning:—

The increase in violence and intensity successively on a rising scale; the ever forward movement of the locusts towards tracts more distant from the ghâts into more intensely cultivated regions near the sea-board.

By this time, with reference to these two points the invasion attained its maximum in the month of February 1904. On no previous occasion were the clouds of locusts so numerous and dense or had they so much approached the sea, penetrating into many a kilometer of Bardez district and reaching the western portion of the districts of Ilhas.

Probable causes of the non-permanence of locusts in Goa.

8. The non-permanence of the locusts in the Portuguese territory of Goa with regard to their retreat in November and December might be accounted for by the great fall of temperature in those months at night at the foot of the ghâts and the heavy dews almost akin to rain which soaked the soil between sunset and sunrise. It must be admitted that this explanation does not show the reason why instead of retreating eastward they did not move westward where the night temperature is equal to the day temperature with

a slight difference, where there is no dew and where there is no lack of things to feed on, besides the north-easterly wind would have helped them to go westward.

As to the retreats about the end of March or beginning of April, they should be ascribed to the strong winds which about this time begin to blow from the sea ; this also accounts for their not having been able to penetrate into tracts nearer the seaside in spite of the repeated attempts made this year.

II.

Breeding soil of locusts.

Egg-laying and hatching.

9. The very fact of the non-permanence of locusts in the Portuguese territory of Goa (the annual invasions being composed of three partial ones, of which the most persistent lasts but two months) leads to the conclusion that the insects do not lay eggs at Goa.

Observations support this conclusion, for no young locusts in larval and unfledged stage have been found in Goa, except in very insignificant numbers, neither batches of eggs. But all the same, bearing in mind the virulence of the invasion of this year, the necessary investigations have been instituted to find out whether locusts are being hatched in this country and to what extent.

III.

Points and direction of the locust invasion of the Portuguese territory.

Points of invasions of Portuguese territory.

10. The locust invasions have generally penetrated the Portuguese territory of Goa through the north-east angle, Satary being the first place to suffer. The locusts appear to come from Kolhàpur and Belgaum into our territory, entering it at Satary and spreading thence over the rest of the country. But when the invasions become very dense, the points of ingress are more numerous and extend over the eastern frontier line and southern limit of Goa, the locusts advancing protected as much as possible from the prevailing winds.

IV.

Preventive measures taken against the locusts invasion.

Steps taken against the invasions.

11. All the measures devised against the locusts are mentioned in the Government Notification No. 34* of the 3rd February of this year, which accompanies these notes.

Published as it was while the enormous invasion by acridiæ was at its highest stage, there was some hesitation in the execution of some of these measures, so that it was not possible to appreciate the results that might have been expected. At any rate the following conclusions appear reliable :—

(*a*) When the invasion is intense and violent, as in February this year, hardly any results may be expected.

(*b*) When the invasions are less violent, the adoption of the measures indicated in paragraph 8 of the instructions that accompany the Notification

* Not printed.

No. 34*, such as rattling of tin pots, burning fireworks, &c., gives results, because in this manner it has been often possible to drive away the locusts into uncultivated areas, and to prevent their entering more intensely the cultivated lands. Even during the great invasion of February the enormous columns of locusts were by these means prevented from entering the districts of Salsete and Bardez.

(*c*) The emulsion of soap and petroleum gave no results at all.

(*d*) Fires hardly gave any result.

(*e*) Bagging or catching the insects always gave good results; they are immediate when the invasion is not great, and futile when the invasion is exceptionally severe.

It would be advisable if the British Government had made bagging compulsory in the invaded areas. The study of the means of destruction of the acridiæ and their application, although they may not appear to produce great success, yet it is the duty of all Governments.

The fact that bagging does not produce immediate results causes it to be considered useless, regardless of the circumstances that the invasions have to be reckoned with for a series of years, and that the apparently insignificant results therefore, enhanced by the destruction of female locusts.

Catching can be carried out with comparative facility, and good results in Goa, at nights and before daybreak, when the locusts are in a torpid condition owing to dampness and dews. During the day it is far more difficult, but gives good results in certain kinds of lands.

The Notification No. 34 prescribes *compulsory free* labour for the destruction of locusts, of 48 hours per year on consecutive days or otherwise for each man of the invaded region between 15 and 50 years of age; *compulsory paid* labour, besides free labour, being compelled to produce 4 curos of locusts payable at the rate of one anna and six pies per curo; *voluntary remunerated* labour at the rate of one anna and six pies per curo brought in.

It is believed that if unfortunately there should be new invasion, as it is feared, then the labour of these working hands, being properly organised and supervised, must produce satisfactory results.

V.

Final remarks.

Damages, necessity of warning of the approach and of measures adopted for destruction.

12. The damages caused in the current year by locusts in Goa territory were very great, but not to such extent as the farmers would make it believe. But the damages will be enormous if the locusts succeed in invading the sea-board regions and destroying the leaves of the numerous magnificent paying cocoanut trees, which are one of the principal sources of the revenue of the country. This is a cause of constant

* Not printed.

anxiety to us, and it would be well if the Governments of British India would warn us of the approach of the locusts of our territory, and of the kind of aspect which the invasion bears, informing us also what measures have been adopted for the destruction of locusts and results obtained.

(Signed) T. M. PEIXOTO VIEIRA,

GOVERNMENT SECRETARIAT, *Chief Secretary.*
6th August 1904.

KOLHAPUR.

The following is extracted from the information published by Government of Bombay:—

Copy of letter No. 102, *dated the* 19*th March* 1905, *from the Chief Revenue Officer, Kolhápur, to the Diván of Kolhápur.*

"With reference to your No. 3827, dated 17th November last, asking me to report as to what measures have been adopted for the destruction of eggs, hoppers and adult locusts and with what measure of success in this Principality, I have the honour to state as follows :—

"It may be generally observed at the outset that the Darbár has throughout assimilated its measures in this matter to those of the British Districts. In my letter No. 207, dated 21st June last, I have already stated in detail how a working establishment was organised to carry out the measures adopted, and communicated to the Darbár, from time to time, by the British authorities, and have also furnished in weekly reports, &c., information regarding the movements and destruction of the hoppers, &c., in this Principality. It would, therefore, be unnecessary to repeat the details again, and the following summary in brief of the measures in question would, I think, suffice for the present purpose.

"First, it is gratifying too bserve that though swarms of locusts were seen all over the Principality in the months of April, May and early June, they did not settle permanently anywhere except in some grasslands and hilly tracts in the Chanwad Mahál of the Panhala Petha ; and almost all the area being free of crops, they did not cause any material damage. The people, therefore, would not readily offer their assistance in destroying these adult locusts, and so they could not be destroyed in any perceptible quantity. In the latter part of June and in July the winged flights were not heard of anywhere. In the beginning of August a report was received from the Chanwad Mahál about locusts in small numbers being seen in a state to lay eggs in the grasslands, &c. On receipt of this information the District Officer, N. D., and the State Forest Officer, to whom the management of the locust operation was chiefly entrusted, were at once deputed to the Ghât Districts to search for the eggs. But in spite of their arduous efforts they could not find any. Some eggs were seen in the ovipositors of killed female locusts. Shortly afterwards, however, the appearance of the young brood in some villages of the Mahál was reported to me, and in the middle of September the young hoppers were seen in some villages of the Panhala Petha. On receipt of these

reports circular orders were at once issued to the working establishment to commence the several operations with the help of the people to whom rewards were offered at the same rates as prevailed in the British Districts. In the beginning the young hoppers were so small that as many as 1,000 of them weighed in one tola, and would be found very difficult to destroy. Some 67 persons could not, with hard labour, destroy more than 102 tolas in one day. Young hoppers were also reported to have appeared in the vicinity of the Alta Hill, but on account of their small size they could not be identified with the Bombay locusts. A few of them were, therefore, sent in a tin to Mr. Tudor-Owen, who, after subjecting them to microscopic examination, informed me that they were mostly "long-headed rice grasshoppers." They being, however, destructive to rice crops, he strongly urged upon me the necessity of destroying them. Intructions were also received from the Director of Land Records and Agriculture for destroying all kinds of hoppers indiscriminately, and circular orders were issued accordingly. Generally the use of the bags attached to bámboo frames, suggested by H. Maxwell Lefroy, Esq., Entomologist to the Government of India, and communicated to me under your No. 2662, dated 3rd August last, was adopted, the materials required being supplied at the State expense. In some cases where the method was found inconvenient, simple bags with strings attached to the four corners at the opening without bámboo frames were rapidly dragged over young crops and the hoppers collected therein were destroyed by twisting the bags. In this way nearly 24 maunds in weight of hoppers were destroyed last year.

"The Kárbhári of Bávda reports that by adopting similar measures, for which he received instructions from time totime from me, some ten maunds and a half weight of hoppers was destroyed within the limits of the Feudatory estate."

Letter No. 101, *dated 20th January* 1905. *To the Political Agent, Kolhápur and Southern Marátha Country.*

Sir,

With reference to your No. 4605, dated 12th November last, forwarding copy of Government Resolution, Revenue Department, No. 8435, dated 1st idem, I have the honour to submit the following information furnished by the State authorities of all the States under my subcharge, regarding measures taken by them for the destruction of eggs, hoppers and adult locusts :—

Sángli State.—No eggs and hoppers were found in the State ; some thin swarms of green locusts had made their appearance in October last in some villages of the State. But their stay was nowhere longer than four days, and they did not do any appreciable damage to crops. They could be caught by hand on foggy mornings when settled on the fields. About 206 lb. of locusts were destroyed in this way by the owners of the fields. At present all the villages in the State are free from locusts.

Miraj Senior State.—Many swarms of locusts had appeared in the villages of the State during the summer and also in the month of October. They stayed a very short time, and many died from cold during the first few days of

November. No eggs or hoppers were observed, and there are at present no locusts in the State.

Miraj Junior State.—Only one swarm of locusts appeared in October last, but it was thin, and did not do real harm, and consequently no measures were adopted for their destruction.

Kurundvád Senior State.—As no eggs were deposited within the limits of the States, no measures were needed for their destruction.

Kurundvád Junior State.—No eggs of locusts were found in any tálukas of the States except Yalur, where hoppers were destroyed by means of a bag mentioned in the brief note on locusts dated 13th April 1904. At present there are no locusts in the State.

Jamkhandi State.—Swarms of adult locusts had appeared in June last, and as their stay was very short and no appreciable damage was done to the crops, no special measures were taken for their destruction.

Mudhol State.—As neither hoppers nor adult locusts have reappeared since their last disappearance in summer, no measures were taken for their destruction.

Rámdurg State.—No eggs of locusts were found in the State, and consequently there arose no necessity for their destruction.

I have, &c.,

R. S. POTTINGER, *Captain,*
Assistant Political Agent, Kolhápur
and Southern Marátha Country.

APPENDIX B.

EXTRACT FROM A REPORT.

No. $\frac{3513}{1\text{-}126}$, *dated the 24th June*, 1905.

By B. P. STANDEN, Esq., I.C.S., C.I.E.,

Commissioner of Settlements and Agriculture, Central Provinces.

Arrival of the locusts and preliminary measures taken.—In October 1903, the arrival of locusts in small numbers was reported from the Chikhli and Malkapur taluqs of the Buldana District, and in November a similar report was received from Akola. Little or no damage was caused to crops and the locusts very soon disappeared. The pest, though active, I believe, in the Bombay Presidency throughout the cold and hot weather, left these Provinces unmolested until May 1904. On the 26th April the Bombay Government warned us that swarms of locusts were reported from the Deccan and Southern Maratha districts, travelling eastwards, which might invade these Provinces.

On the 20th May, the Deputy Commissioner of Buldana reported their appearance in the Chikhli taluq, and between this date and the middle of June the insects spread rapidly over the whole of Berar and the western districts of the Central Provinces. The tracts infested were, in addition to Berar, the districts of Nimar, Hoshangabad, Betul, Chhindwara, Wardha, Chanda, and the greater part of Nagpur, and throughout the period during which the pest was present these limits were never exceeded.

As soon as reports of a widespread invasion were received, Deputy Commissioners of the infested districts were instructed to send specimens of the insects to the Government

Entomologist, Mr. Lefroy. It was, of course, of the highest importance to ascertain whether the locusts had already laid eggs or were about to do so, for on this would depend the question whether the country was to suffer from a really serious plague of the insects. The full grown locusts which had arrived, though very numerous, were not banded in swarms, and the damage which they could do at a time when there were no crops on the ground was of comparatively slight importance. Mr. Lefroy reported that the specimens sent to him contained immature eggs, and that egg laying might be expected to begin soon. Instructions were issued to impress upon the people the gravity of the threatened plague, and a search for eggs was recommended. Meanwhile I asked all Deputy Commissioners to report the arrival of locusts in their districts, and suggested the appointment of special officers of the standing of Naib-Tahsildars to supervise operations, and the division of districts into circles supervised by capable Patwaris. It was important that measures for a campaign should be organised before the appearance of the young hoppers.

Towards the end of June the locusts began to couple, and soon afterwards egg laying began. Coupling and egg laying lasted about a month, and were over before the end of July. These functions mark the end of the locust's life, and the insects now rapidly died off. By the beginning of August they had practically vanished. The next development to await was the appearance of the young hoppers. Mr. Lefroy kindly offered to pay a flying visit to Berar and examine the situation there, and on the 16th July he met the Commissioner and myself at Amraoti. The question of making payments for the destruction of locusts was discussed, but it was decided not to attempt this, owing to the difficulty of measuring payments by results, and the risk of peculation which would be present if payment of money were entrusted to numerous subordinate officials. The best plan seemed to be the sub-division of districts into circles under officers who would explain the importance of the matter to the villagers, show them the best means of fighting the pest, and, as far as possible, see that they

availed themselves of these means. Mr. Lefroy explained several methods of destruction, which will be described later, and it was decided to explain these methods at a meeting of special officers to be held at Akola. This meeting was held on the 20th July, when I took the opportunity of explaining to the special officers who had been sent from all districts of Berar, and a number of native gentlemen invited by the Deputy Commissioner, the general plan of campaign, and of showing them samples of the mechanical contrivances recommended by Mr. Lefroy. The special officers were then sent back to their districts, and Deputy Commissioners of all the infested districts were recommended to place a special officer in charge of the operations in each tahsil or taluk, while Revenue and Circle Inspectors and selected Patwaris were to be put in charge of circles under the supervision of the special officers. Every effort was to be made to explain the gravity of the situation to the cultivators, and villagers were to be shown how to prepare apparatus for the destruction of the locusts. The special officers were to be of the standing of Naib-Tahsildars, new appointments being created, if necessary. Copies of a memorandum by Mr. Lefroy, in which various contrivances for hopper-killing were described, were sent to all districts except those from which special officers had come to the Akola conference. In addition to this, a note was drawn up in my office describing the life history of locusts and the developments of the pest which might be expected. This note was sent to all the affected districts, and translations in Hindi or Marathi were widely distributed and published in the *Agricultural Gazette*.

Methods and contrivances experimented with. (i) *The American "hopper dozer."*—This is a bag on a sledge. On the sledge-runners a bag is erected in such a way that it will stand up well when the sledge is running, and can be easily and quickly collapsed when the haul of hoppers is to be destroyed. The bag has a wide open mouth facing in the direction in which the sledge travels, into which the hoppers jump when the machine is about to overrun them. This contrivance was found to be

heavy, expensive, and not very efficacious ; it cannot be used in crops or on rough ground, and may be said to have been a failure. No further description of it is therefore necessary.

(ii) *The Russian wheeled revolving brush.*—The principle of this contrivance is similar to that of the revolving brush used for sweeping mud from streets, except that the axis of the brush is at right angles to the direction in which the machine is travelling instead of being placed obliquely. The machine consists of two wheels and an axle which revolves with them. Thorny bushes are attached to the axle which has holes prepared to receive their stems. A bag is fastened behind the machine, and as the axle revolves the locusts are brushed up into the open mouth of the bag. This was found fairly successful, but the machine is expensive and the fixing of the bag in such a way as not to interfere with the rotation of the axle and wheels requires no little ingenuity. Cheaper and more effective contrivances were devised, and this machine is therefore not recommended.

(iii) *The capacious bag.*—This is made of cheap country cloth and resembles a huge bolster-case about ten feet in length by six in breadth, with one of the long sides open. Two men take each one of the corners at the end of the open side and drag the bag rapidly over crops. The locusts fall into the bag, which can then be twisted up and the insects crushed. This was found effective and has the advantage of cheapness.

(iv) *The bag and frame.*—This contrivance was suggested by Mr. Lefroy, and proved very successful. A light bamboo frame is prepared and placed inside a bag, one side of which is open and kept open by the frame. Cords are attached to the frame and it is drawn rapidly over the ground. Hoppers get into the bag, which is periodically taken off the frame and the hoppers are crushed. This contrivance is very light and can be easily worked by one man. When it is to be drawn over crops the frame can be taken out, and the mouth of the bag be kept open by two bamboos. The absence of the frame obviates all risk of damage to crops. This contrivance

was most successful so long as the crops were young and of small height. A full description of it was given in a leaflet which was translated into Hindi and Marathi and widely distributed.

(v) *Poison.*—All poisons are very dangerous owing to the risk of the poisoned grass or other substance being eaten by cattle. Mr. Lefroy, however, recommended a preparation composed as follows :—

Lead arseniate	...	1 lb.
Jaggery ...	...	5 lb.
Water ...	...	100 gallons.

This mixture may be sprayed upon fodder, or fodder may be dipped into it without harming cattle. It is said to kill locusts. A great objection to the use of poisonous mixtures is the difficulty of finding out to what extent the locusts have been destroyed, since the dead insects are at once carried off by birds, ants, etc. The lead arseniate mixture was tried in Nagpur, but was received too late to be given a fair trial. It failed completely in Wardha.

(vi) *Beating with brooms and branches.*—This is the simplest and most effective way of dealing with the locusts before they have developed wings. Winged locusts can also be destroyed by this method with the utmost ease when in the act of coupling, as they then make no attempt to escape, and a single blow from a broom or branch will destroy the pair. It is, of course, of the highest importance to destroy the locusts at this stage, as the destruction of each female prevents the laying of a hundred eggs or more. In places where the people were willing to destroy the locusts they took readily to this method and children were frequently thus employed.

(vii) *The borax and tamarind mixture.*—A mixture of borax and powdered tamarind leaves was tried as a means of poisoning the insects. It failed almost entirely.

(viii) *Bonfires.*—Bonfires were lighted at night in order to lure the locusts to self-destruction. A few are said to have been thus destroyed in Basim after the insects had begun to swarm, but elsewhere the experiment was a failure.

(ix) *Kerosene oil.*—Kerosene was tried in all districts, and the Nimar report contains an interesting account of the experiments made and an estimate of their results. I quote from the report :—

"Kerosene oil was used in several places for the sake of experiment. Half kerosene oil and half water was sprinkled in fields abounding in very young hoppers and it was observed that they died immediately. The experiment was repeated in three or four places and was found successful. But it failed where the hoppers had changed colour and had grown to an inch in size. Only pure kerosene oil could cause their death. The method was costly and could not be pressed on the people. Besides, it was reported from one or two places that the crops standing in places where oil had been sprinkled had withered. This however, was due to want of moisture in the fields. In a paddy field at Palsud, where hoppers swarmed in large numbers, kerosene oil was sprinkled, and the area was marked with a view to seeing its effect. There was rain in the evening and on the days following, and no injurious effect was produced on the crop. Some people said they had made the same experiment last year, but without any success. But they said no injury was done to their crops. The reason why their experiment failed was that they tried it when locusts were full grown. Fully-grown locusts do not die unless they are actually steeped in the oil. The bigger the insect the greater is the quantity and strength of the oil required.

Kerosene oil can be used with advantage where the crops are high, and where bags and cloths are of no avail. Iron or brass pans are placed at several places in a field teeming with hoppers, and the hoppers are driven with branches towards these pans from all sides. When pressed from all sides they jump into the pans and die in a short time. When the pans are full the hoppers are taken out and thrown away. The oil is left for further use. This method does not cost much, but is laborious. It is to be employed as a last resort in fields where, owing to the height of the crops, other methods cannot be employed.

One method does not succeed everywhere. The methods must be changed or modified according to circumstances."

Development of the pest and the campaign against it.— Hoppers appeared in the first week of August, and hatching was general almost throughout the month. As soon as it appeared in each district that the insects were present in sufficient numbers to warrant active measures being taken against them, the supervising agency was brought into existence and set to work. The organisation in the different districts was generally on the same lines, a specially appointed Naib-Tahsildar being placed in general charge of the operations in each tahsil. Villages were grouped in batches of 25 or 30, and these groups were placed in charge of selected Patwaris, or in Berar, of Patels. Revenue and Circle Inspectors were employed in supervising the work of the group officers, and the duty of all the supervising officials was to tour constantly in their charges, show the people the best way of fighting the pest, and to induce them to take measures of self-defence. Paid labour was not employed by Government except to a limited extent in Betul, Ellichpur and Akola. In Akola Rs. 130 and in Ellichpur Rs. 250 were spent in Government forest areas. Many Malguzars, Patels, and wealthy cultivators, however, organised and paid for labour. In Hoshangabad as much as Rs. 9,290 is said to have been privately spent in this way. In Wardha some members of Local Boards showed a keen interest in the campaign, and rendered most useful assistance. Samples of bags and other contrivances were shown to villagers, and they were encouraged to make them for themselves.

Under instructions from the Secretariat a weekly report on the locust visitation was sent by me for the information of the Chief Commissioner, and to enable me to do this the Deputy Commissioners of the infested districts sent me similar weekly reports on the subject.

An Entomological Assistant of the Agricultural Department was instructed to tour in Berar, and gave some well-attended demonstrations of the best methods of hopper-killing.

All the methods of destruction mentioned above were tried, and the cheaper ones were almost universally found to be the

most efficacious. At the end of August the migratory juari bird ("rosy pastor," vernacular *bhordi*), which generally appears just before juari comes into ear, arrived. Owing to the unwonted earliness of its arrival, and the fact that its plumage, which changes as the season advances, had not yet taken the colour familiar to the people, there was at first some uncertainty as to its identity with the well-known annual visitor. Little was heard of it in September, and even as late as the beginning of October it was mentioned in a Chhindwara report as "a new bird from the south." It now seems to be generally agreed that it was the familiar juari bird. In October these birds rendered remarkable assistance in clearing off the pest. Large flocks of them appeared, and in some places made a clean sweep of the insects, which by this time had left their grassy breeding places, and were attacking the juari crop. Other birds which readily devoured locusts were minas, kites and crows. Even foxes, cats and dogs are said to have eaten them occasionally.

The crops which were most generally attacked were juar, tur, mung, rice, and the lesser millets. Tur suffered most, but easily recovered after rain. Rice was seriously damaged in parts of Betul, where its cultivation is confined to small low-lying patches of land. The crop is greedily attacked by locusts, and it is fortunate that it is a comparatively insignificant crop in most of the tracts which were infested. The invasion, in fact, just stopped short of the true rice country. On the other hand cotton, which greatly predominates in nearly all the tracts invaded, seems to possess little or no attraction for locusts, and escaped almost untouched. Juar was readily attacked, the leaves in some fields being thoroughly riddled and remaining like mere skeletons of themselves.

The young ears of juar and also of rice were attacked so long as the grain was in the "milky" or soft stage. The very young hopper seems to like grass as much as any other food, and it was only when the insects grew to about an inch in size that they attacked the crops in large numbers. Owing to this habit of clinging to their hatching grounds, the measures taken

against them and the valuable aid given by birds and other natural enemies of the locusts, the extent of the damage was nowhere serious, and no necessity of rental or revenue remissions arose, nor do the people seem to have expected anything of the kind. I am inclined to think that an estimate of two annas damage in the rupee over the whole area affected is beyond the mark, and in some places no damage whatever was caused. A remarkable feature of the life history of the Bombay locust—and here it differs entirely from the marching locust of Cyprus and other places—is its unwillingness to leave the place of its birth until its wings have grown and it is capable of flying. In many villages some fields might be found in which the crop was damaged by hoppers to a really serious extent, in some cases being even left unharvested, while in other fields of the same village similar crops would escape quite untouched. The only reason for this must be that the fields invaded adjoined the places where eggs had been laid, and the hoppers hatched.

The season is believed to have been favourable to the pest. The monsoon rainfall was considerably below the average, and bursts of rain were followed by long breaks. There is much diversity of opinion on the effects of rain on locusts. It is generally agreed that after the hoppers have passed beyond the early and helpless stage, rain causes them little, if any, harm. But as regards its effect on very young hoppers opinions differ. In Wun hoppers were found dead after heavy rain, and in September parts of the Melghat were said to have been completely cleared of hoppers from the same cause. On the other hand, many officers think that rain has no effect on the insects. Nothing, then, has been proved. Young hoppers would probably be washed away and drowned by a flood.

In Betul locusts nearly fully grown were found dead and infested with a tiny red parasite. This parasite was also found in Wardha. The Entomological Assistant found it present in Nimar, but could not discover that it caused any harm to the locusts. They were, however, killed by a kind of grub, which subsequently developed into a fly not unlike the common

house-fly. Specimens were sent to the Entomologist to the Government of India, but I have not heard whether they have been identified.

In the middle of September, under instructions of the Director of Public Instruction, all rural schools in the affected districts were closed, in order to enable the schoolboys and their masters to learn the methods of locust destruction, and themselves aid in the work. This order was received with some dissatisfaction by parents of boys of the better castes, and it required strong personal influence on the part of the Master and Malguzar or Patel to give proper effect to the scheme. In many places, however, the boys were most useful and willing helpers. The schools remained closed for about six weeks.

As the cold weather approached, the method of catching locusts by hand, when they are torpid and benumbed, was successfully practised, but cultivators were generally too busy with rabi sowings to give much further help.

Before the end of October the locusts began to manifest the swarming instinct, and in the beginning of November migratory movements were noticed. These movements were generally in a westerly direction, and continued throughout November. By the beginning of December locusts had entirely disappeared and with them vanished all fear of damage to the valuable rabi crops, which had just germinated.

Attitude of the people.—Except in Nimar, where locusts have done some damage of recent years, it was at first very difficult to awaken the people to a sense of the calamity with which they were threatened, and even when the young hoppers appeared in large numbers they were believed to be ordinary grasshoppers, such as often appear in places during the rains. There was a universal belief that the locusts were a manifestation of the power of God and a sign of the divine wrath against the sins of men. Sadhus and fakirs, of course, took care to foster this belief. Recourse was therefore had to various forms of worship and incantation. The most common practice was to make images of the insects in clay, or even gold, and then worship these. Often a few locusts would be caught alive, and

after food had been placed before them they were worshipped and begged to go away. A common vernacular term for the locust is *ghoda* (horse), and there was a widespread belief that the insects were the horses of the god Mahadeo sent to ravage the land as a sign of his wrath. A curious belief was current in the Satpura districts of Betul and Chhindwara. The god Mahadeo lives in the Pachmarhi hills, and an estate near Pachmarhi has been taken under the management of the Court of Wards. Mahadeo has not received proper worship—so ran the story in Chhindwara—since the estate has been thus assumed, and showed his anger by sending the locusts. In Betul the story took a slighty different form. There, it was believed, that the estate has a ravine which is a sort of locust preserve, and that the locusts, not being properly looked after and fed under the Court of Wards, emerged and ravaged the surrounding country. The belief in a place as a stronghold of locusts has its counterpart in Chhindwara, where a hill named "Tiddi kot" or "Tiddi ghar" in the Almod Jagir is believed to be the home and breeding place of the insects. Enquiry and inspection, however, showed that the locusts were no more numerous there than elsewhere. Another common belief was that for each locust destroyed two would appear, and this belief, as the Deputy Commissioner of Betul points out, is not so unreasonable as it seems, for as the young hoppers grow in size they leave the patches of grass in which they are hatched and invade the crops, thus apparently increasing in numbers in spite of all efforts to destroy them. In some of the Maratha districts it was believed that the sprinkling of water taken from sacred tanks and other holy places would have the effect of banishing the pest.

As the young hoppers grew in size and it became apparent that they were damaging the crops, the apathetic, not to say antagonistic, attitude of the people was to some extent broken down. It was seen that Government was in earnest in its efforts, and some credit was even given to Government for having foreseen that hoppers would appear after the old locusts, which appeared in June, had disappeared, and for taking steps to warn the people in time. In the Sulgaon Circle of Nimar the

people took readily to the work of destruction, having seen their crops damaged by locusts in the previous year. Generally speaking, the people were more amenable to reason in the Maratha districts than elsewhere, and in Wardha they are said to have displayed so much keenness in the campaign that in some villages lists of cultivators were framed and the number of locusts destroyed by each was daily noted against his name. Good work was also done by villagers in Basim, Buldana and parts of Chanda. As might be expected, the higher castes like Brahmans, Jains, etc., were most averse to the work of destruction, but even the higher castes were ready to employ hired labour for the work as soon as the menace to the crops was felt to be a real one. Low castes like Mahars, Gonds and Korkus showed little reluctance, and in some places exerted themselves strenuously. When the village schools were closed in order to allow of the help of the schoolboys being utilised, many of the parents among the higher castes were strongly opposed to their children being employed in the work of killing locusts, but the boys themslves took gladly to their new occupation and derived a good deal of amusement from the work. In many cases village schoolmasters rendered most useful help. The extent to which the people were willing to cooperate everywhere depended largely on the energy and influence of the supervising officials, and should there be another locust invasion in the near future, it is hardly likely that so much initial opposition will have to be overcome again.

Estimate of the success of the operations.—It is, of course, impossible to form any but the roughest estimate of the degree to which the pest was diminished by the operations taken against it. The Deputy Commissioner of Wardha considers that a third of the total number of hoppers was thus destroyed, while some malguzars in his district estimate the proportion as a half. From what I saw in the neighbourhood of Hinganghat I have little doubt that the efforts of the villagers had an appreciable effect on the numbers of the insects. Our efforts were aided in remarkable fashion by juari birds ("rosy pastor"), which arrived in large flocks earlier than usual, and devoured

the locusts greedily. They arrived just at the time when the young hoppers had grown large enough to be active and formidable, and it is believed that enormous numbers of the insects were destroyed by them. It is possible that the preservation of the crops was due as much to these birds as to the efforts of human agency. Lastly, the pest suddenly disappeared when it had become impossible to take effective measures against it. As soon as the locusts were fully grown and had developed the power of flight, they entirely vanished in the course of a few days, migrating, it is supposed, to the ghâts of Bombay, where the Deccan locust is believed to have its home.

APPENDIX C.

REPORT BY THE DEWAN, RAJPIPLA STATE, ON THE LOCUST INVASION OF 1904.

THE first appearance of locusts in the State during the year was on the 18th of April. It was in the Dediapada Taluka, which forms the Eastern part of the State. They probably came from the Khandeish Mehwas territory lying to the East of the said Taluka.

2. A second flight of locusts passed over a portion of the Gardeshwar Taluka, which forms the North-Eastern corner of the State, on the 19th May. This swarm is also believed to have come from the East; in the present instance, from the Kanti Estate of the Khandeish Mehwas.

3. Locusts had appeared during the previous year also (in October 1903) in the same localities and had spread from there to some villages in the West. They did some damage, but the only remedy tried was the ploughing up of bits of land in which locusts had remained and where it was possible they might have laid eggs. Owing, however, to uncertainty in this respect, and to the vastness of the areas involved, it was not possible to do much in this direction, and the results achieved were inappreciable, although a serious attempt was made wherever possible to plough up lands suspected to contain eggs. Not many eggs would appear to have been laid, however, and the locusts themselves either passed on or perished after doing some local damage.

4. The two flights of locusts, referred to in paras. 1 and 2 above, which appeared in 1904, were duly reported to Mr. Maxwell-Lefroy, Entomologist to the Government of India,

whose headquarters—luckily for this part of the country—had at that time been established in Surat, and specimens were sent to him in accordance with orders issued by Government on the subject. The fact that these flights did not pass away, as was at first hoped they would do, but lingered over different parts in the North and the East of the State, gave rise to serious apprehensions. The methods, originally recommended, of destroying locusts (screens, oilcloth strips, etc.), were not such as would at all answer in a tract of country like this, and it must also be admitted that the proper working of these was not correctly understood and the said methods did not, therefore, appear quite feasible. (The only methods which we did understand and attempted to put in practice were (1) that, already referred to, of ploughing up lands in which eggs were suspected to have been laid, and (2) trying to kill as many locusts as possible by means of long bamboos with brushes of palm or khakhra leaves, etc., attached to one end.) An application was, therefore, made to Mr. Lefroy for information as to whether there was any district in which the methods above referred to (screens, oilcloth strips, etc.), or any others, were being practically put to the test with even a moderate amount of success, in order that arrangements might be made for sending an intelligent official to that district with a view to his gaining a practical insight into the details of the operations in progress there. There appeared, however, no place where such measures were being successfully undertaken.

5. Mr. Lefroy was, however, good enough to furnish us with most valuable information, from which we, for the first time, learnt many important facts. For instance, the experience gathered from the appearance, at very rare intervals, of huge flights of the Central Asian locusts (the *Acridium peregrinum*) had taught people here that these foreign locusts flourished most in dry weather and that eggs would be hatched only in dry sandy places, while rain would prove destructive to locusts and to eggs alike. From the information which Mr. Lefroy was good enough to furnish most freely to

us, we learnt that far from proving destructive to locusts or eggs, rain would help, was in fact necessary for the propagation of the pest, that eggs were laid only in soil soaked with water to a depth of two inches or more, and that dry soil was not suitable for egg laying. We found that the locusts we had to deal with (the *Acridium succinctum*) were, although perfect foreigners here like the Central Asian locust, the *Acridium peregrinum*, an altogether different variety from the latter, and that they flourished only under the above conditions. The information thus obtained through the kindness of the Government Entomologist was of great value in helping us to a correct knowledge of places where eggs were likely to be found and where hoppers would very likely appear. We also learnt from Mr. Lefroy the probable period of incubation. It thus became very much easier than it had ever been before, to search for, and destroy, locusts' eggs and to be prepared for the appearance of hoppers with a view to their being destroyed before they were able to fly. I beg to append translation of a Circular Order (No. 2, dated the 8th July 1904) issued with the above object, marked Appendix A. Rewards were given at the rate of three annas per lb. of locusts and one rupee per lb. of eggs.

6. Soon afterwards, Mr. Lefroy was good enough to favour us with a visit, when he saw some of the villages in the vicinity of Nandod where locusts had been, and favoured us with further very valuable information and suggestions. Further orders for the destruction of eggs and of hoppers—as soon as they should appear—were issued and were carried out by the Taluka and Village Officials to the best of their ability.

7. On the 23rd of July 1904 Mr. Lefroy issued a pamphlet describing a simple and effectual method for the destruction of hoppers by means of a bamboo frame having a bag attached to it. He was so kind as to favour me with a few copies of this pamphlet as soon as it was out. The method described was perfectly intelligible, and a frame and bag were prepared at once in accordance with the directions and trials made with it. The results went beyond our expectations as will be seen

from the following extract from a letter addressed to Mr. Lefroy on the subject:—

"In continuation of the concluding portion of para. 2 of my letter No. 99 of the 27th instant, I have the honour to state that as soon as the first bag and frame were ready an experiment was made at a village about three miles from Nandod in a field near which locusts had been seen coupling. The field was about five acres in extent and was all grown over with grass which is, of course, as yet but small. The result of an hour's work in the field, under the personal supervision of the Suba, was the collection, in the bag, of a quantity of grasshoppers, locusts, and hoppers of various kinds which I do not find it possible to determine. I beg to send the whole lot by parcel and to say that the quantity is small *because the number of these insects in the field was small.* Otherwise, the experiment has clearly shown that the frame and bag work very nicely and effectually, that any number of hoppers that there might be in grass-land, or a grass border, or any other land, where the frame and bag could be used without fear of injury to crops, would be certain to be caught and that once inside the bag, escape would be impossible."

8. The cost of the first bag and frame made here was Rs. 5. Six more were made and sent out to each of the Talukas with detailed instructions embodied in a Circular (No. 9, dated the 1st August 1904), a translation of which is appended hereto as Appendix B. Three more were subsequently sent out to one of the Talukas (Dediapada) where need for action on a larger scale was felt more than in the other Talukas. These ten bags and frames, made at State expense, were for general use and for concerted action under official supervision, and instructions were given for others being made by individual cultivators the cost to whom would, it was pointed out, be much less than to the State. Everywhere the arrangement—worked as directed in Appendix B—proved thoroughly successful. Where crops were likely to be injured by the frame, the bag was used with two pieces of bamboo in

the place of the frame, in accordance with instructions given by Mr. Lefroy, and the experiment answered perfectly.

9. It fortunately so happened that a great proportion of the eggs laid were spoiled by some disease, or perhaps by reason of the prolonged drought, and did not hatch. A large proportion did produce hoppers, however, but many of these were destroyed by birds. (This had been the case with the grown-up locusts also even before the egg-laying period. It was remarked that the birds came after the locusts in unusually large numbers, and rendered great service in destroying the locusts, as they did, at a later stage, in destroying the hoppers). Large numbers of hoppers remained, however, and for ridding us of these, Mr. Lefroy's bag and frame arrangement was of the greatest value. The results, wherever it was used, were of the description noted in the concluding part of the quotation in para. 7 above.

10. In one village of the Valia Taluka, hoppers and locusts appeared as late as the end of September. They were confined, however, to a few fields situated close to some ravines of a description peculiarly favourable to the laying and hatching of locusts' eggs. It is worthy of notice that these fields were under fully grown Juvar crop. Mr. Lefroy's method was tried in these fields, however, with complete success, 26 lb. of hoppers and locusts (all that there were in the said fields) being destroyed in the course of a day or two ; and, as far as can be ascertained, there are now no locusts or hoppers anywhere in the State.

11. The huge flights of the Central Asian locust (the *Acridium peregrinum*) which, formerly passed over these parts, at rare intervals, struck terror into the hearts of the people. The damage done by them was immense. But it was localized, being restricted to the tract they passed over, and nothing more. The locusts passed away, generally the morning after they arrived, and the damage doing was confined to the day or two of their halt. The swarms of the *Acridium succinctum* which have been visiting these parts during recent years, though perhaps, less terrifying in aspect, do more real damage, and

damage of a much more permanent character. They do not pass away immediately, or in a day or two, but come "to stay," as it were, and to propagate their species. They are to be dreaded, therefore, not only for the damage they themselves caused, but quite as much, indeed a great deal more, for the damage which their progeny would be certain to cause, if some effectual measures could not be devised for the latter's destruction. It is fervently hoped that the arrangement devised by Mr. Lefroy will prove an effectual remedy of a permanent character.

DHANJISHA EDALJI,

Dewan, Rajpipla State.

Circular Order No. 3, *dated the 8th July* 1904, *to the Suba and to the Thanadars and other Taluka officers* (*also notified to the public.*)

Locusts.

From observations and investigations made by the Entomologist to the Government of India it appears that ordinarily—

(1) After heavy rain locusts may be expected to be found coupling.

(2) Within two days, and at the most within a week, after this, the female locusts begin to lay eggs.*

(3) Egg-laying will take place in soil soaked with water to a depth of three inches or more. The female locust digs into the surface of the soil and buries a portion of the body in it. In the hole thus formed the egg is laid.

(4) The eggs are held together in a mass, each mass being about three inches long. One thousand such masses weigh one seer and contain from 1 to 1½ lakh of eggs. A quantity of locusts, males and females weighing five seers, would be equivalent to (*i. e.*, capable of producing) a seer of eggs.

* This will generally be in the same place in which the locusts were found coupling.

(5) The holes in which eggs are laid are easily distinguishable. They are a little larger than a lead pencil in diameter and with loose soil thrown round the rim, as if a worm had brought up the soil. A little below the surface a smooth even surface is seen as if the hole were full of gum or some solidified liquid. The egg mass reaches almost up to the surface. So that although the finding out of the egg masses with a view to destroying them is a very difficult and troublesome job it is not impracticable.

2. The orders given in this office No. 31, dated 14th November 1903, for ploughing up lands with a view to destroying the eggs are now withdrawn.

3. The only means of escape from the ravages of the locust pest in the immediate future are—

(*a*) The catching and destruction of as many locusts as possible, whilst they are coupling, or before then so as to prevent them laying eggs and propagating their numbers.

(*b*) To try and find out eggs as shown in clause (4) of para. 1 above and destroy them.

(*c*) To carefully mark those places where the locusts are found coupling because it is in such places that egg-laying will take place. A proper record of such places should, therefore, be kept and hoppers looked for there, in order that it may be possible to destroy them as soon as possible after they have come out. These hoppers take some time before they acquire the power of flying. Till then they simply hop from place to place, and it is then, *i. e.*, before they are able to fly, that it is easiest to destroy them.

4. Officers and ryots are to carefully bear the above in mind and to take energetic action accordingly. People should be made to understand that it is their duty to exert themselves to the utmost of their powers to free themselves from this great impending danger. If they deliberately fail to do

this it will not be possible for the State to show them any leniency (in the way of remissions, etc.). It is the duty of all village officers to carefully carry out the instructions given in clause (*c*) of para. 3 above. They should be informed that failure in this will be visited with very severe punishment. Carefully prepared lists of the places alluded to in the said clause should be kept and copies forwarded here through the Suba. Constant enquiries should be made at such places to ascertain whether the hoppers have come out of the eggs, and immediately this is found to be the case, effective steps should be taken for destroying them, immediate reports being submitted from time to time.

5. Rewards will be given for the destruction of locusts and of eggs at the following rates :—

	Rs.	A.	P.
For a seer (lb.) of locusts ..	0	2	0*
„ „ „ eggs ..	0	10	0†

Thanadars of Talukas will disburse these rewards wherever they may be in their Talukas. Thanadars' Avalkarkuns will have the same powers at the Taluka head-quarters during the Thanadar's absence from there. The officer concerned should cause the eggs or locusts to be weighed in his presence before giving the reward.

6. Thanadars should, in the first instance, disburse the amounts of these rewards out of their ordinary permanent advances (of Rs. 100 each) and submit weekly bills for recouping the advance.

7. A register of rewards given should be kept in the following form. The principal register should be kept at the Taluka head-quarters, a supplementary register being kept by the Thanadar while on tour in the Taluka. At the end of every week the entries in the supplemental register should be copied into the head-quarters register with requisite explanations :—

---

* Increased to Rs. 0-3-0 per lb.

†Increased to Re. 1-0-0 per. lb. by Circular No. 7, of 19th July 190

Form of register.

Current number.	Date.	Name.	Village.	Quantity brought. Locusts (lbs.).	Quantity brought. Eggs (lbs.).	Reward given. For locusts.	Reward given. For eggs.	Reward given. Total.	Signature of payee.	Signature of officer before whom payment is made.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11	12

Translation (in substance) of Circular No. 9, dated the 1st August 1904. (Rajpipla State).

The attention of all concerned is directed to—

Huzur Circular No. 2, dated the 8th July 1904.
Do. No. 4, dated the 14th Do.
Do. No. 7, dated the 19th Do.

2. These Circulars give orders concerning the measures to be adopted, and the rewards to be given for the destruction of—

(1) Locusts ;
(2) Locusts' eggs, and
(3) Hoppers.

3. As shown in the Circular Orders in question, the grown-up locusts die shortly after laying eggs, and most of them appear to have thus died off.

4. Notwithstanding the offer of a reward of one rupee per lb. of locusts' eggs, the quantities of eggs for which rewards have been claimed so far are insignificant ; and this is not surprising, as it is very difficult to get at these eggs. Moreover, the incubation period is five to six weeks and this much time has elapsed, or nearly elapsed, since the laying of eggs, in those

places in which there is reason to believe eggs were laid. So that in a short time hoppers will begin to come out of the eggs.

5. Much, thus, does not remain to be done in regard to grown-up locusts and eggs. But the rewards offered for both will be still continued.

6. But the great point which requires attention now is the destruction of the hoppers, which, as above, will soon be coming out of the eggs. As shown in previous Circular, these hoppers take some time before they are able to fly, and it is essential that any measures taken for their destruction should be taken before then. If this is not done, there is very little chance of any measures proving effectual after the hoppers have once acquired the power of flying. The hoppers will be able, *from the commencement*, to do much damage to the tender crops. As they grow, their power to do harm will increase, and, once able to fly, they will be able to accomplish the *wholesale and total destruction of crops*, however abundant the latter might be, and there is no measure which can prove effectual for the destruction of such flying locusts. There is only one remedy for preventing the terrible consequences above foreshadowed, and that is *to destroy these hoppers* before they acquire the power to fly. It is the duty of every cultivator to do everything in his power to accomplish this object. The Durbar will give all the assistance they can, but without the zealous and earnest co-operation of the people themselves, all endeavours will be futile. And it is hoped that the people will not fail to exert themselves to the utmost for protecting themselves against the terrible danger above referred to.

7. A very effectual remedy for destroying these hoppers has been devised by the Entomologist to the Government of India. A copy of the Circular issued by that officer is published with this. (Mr. Lefroy's mode of making and working the bag and frame or the bag and bamboo pieces is here fully explained.) A large bag and frame are sent as a specimen to each Taluka. In fields under crops, where the frame cannot work, the two pieces of bamboo sent with the bag should be used for keeping the mouth of the bag open. One such

bag and frame has been practically tested under the personal supervision of the Suba at a village of the Nandod Taluka, and the result has been highly satisfactory. All young grasshoppers and similar insects, as well as locusts' hoppers that there were in the field in which the experiment was made, were effectually caught in the bag, and it was impossible for any of them to escape by hopping out afterwards. Therefore, in every field in which the experiment is tried, it will be possible to destroy all hoppers that there may be in it.

8. The Thanadar of every Taluka should, in the first instance, as soon as he receives the bag and the frame sent as a specimen for his Taluka, practically test it in some field in the Taluka head-quarter station, and, after thus thoroughly understanding its working, should use it in another place in the presence of a large number of agriculturists. (Wherever damage is likely to be caused to the crops by using the frame, the bamboo pieces should be used.) Similar experiments should then be made in the other villages (where locusts had come and remained long enough to lay eggs) under the supervision of the Thanadar himself as far as possible, and of intelligent and zealous karkuns elsewhere. The people should then be instructed to work similarly in their own fields, and they should be made thoroughly and persistently to do this work. The bag and frame could be made by each individual for himself, inexpensively, out of any old cloth and pieces of bamboo, etc. Thus, with but little expense and with zealous work people will be able to ensure protection for themselves. Each agriculturist is bound, in his own interest, to do this work thoroughly and well, and it is the duty of all the Taluka and village officers to see, by exercising efficient supervision, that the people are not negligent in discharging this duty.

9. Each Taluka should, for this work, be divided into several parts, and each division placed under an energetic and intelligent karkun, the Thanadar himself supervising the work in the whole Taluka.

10. Each village should, similarly, be formed into a number of subdivisions, each such subdivision being placed under

one of the Patels or other leading man of the village. If there is a school in the village the services of the master and assistant should be availed of for this purpose. The man thus placed in charge of a subdivision should see the orders given in this circular thoroughly carried out in regard to each field in his division. If any agriculturist is found negligent, requisite steps should be taken through the Talati and Patel, and, failing result, report should be made to the Thanadar. Small waste strips round a field should also be dealt with by the owner of the field.

11. If in addition to the bags and frames sent out from here, it is necessary in any Taluka to have more bags and frames made at State expense, sanction should be applied for through the Suba. Or, if there is urgency, the things may be first made, and sanction to the expenditure incurred obtained subsequently.

12. Wherever it is not possible to make use of the bag and frame arrangement, use should be made of the long brooms with date or brab tree or khakhra leaves, referred to in para. 4 of Circular No. 4 for destroying the hoppers.

If the Thanadar needs the services of men other than his own subordinates he may, as above, utilize the school masters, and also the subordinates of the Police and Forest Departments employed in his Taluka, care being taken to see (with the co-operation of the superior officers of those departments) that the ordinary duties of these officials do not suffer. In addition to giving specific help in this manner, the subordinates of the Forest and Police Departments should, even while employed on their ordinary work, cordially co-operate with the revenue officials as far as they can in carrying out the objects of this order.

13. If the Thanadar considers that the adoption of any measures over and above those ordered by this Circular, would help to secure the desired end, he is authorised to take such steps also, but only as an addition to the action enjoined by these orders. If he finds any difficulty in working according to these orders, report should at once be made through the

Suba who, it is hoped, will personally exert himself with zeal to ensure the success of these measures.

14. If agriculturists are negligent in this matter, they are certain to be involved in great loss. They should be given distinctly to understand, however, that no leniency will be shown to them by the Durbar (in the matter of the collection of land revenue) for any losses which they may thus bring upon themselves.

15. The chief thing which State officials as well as the people have to bear in mind is, that if they sit still and do nothing under the belief that "nothing *can* be done in such matters," there is danger of the most serious loss to all. "Heaven helps those who help themselves," and if persistent and intelligent effort is zealously made, although it is possible that the measures taken may not prove completely successful, there cannot be the slightest question that they will ensure protection from damage to a very large extent.

APPENDIX D.

LOCALITIES FROM WHICH LOCUST REPORTS WITH SPECIMENS WERE RECEIVED, BOMBAY PRESIDENCY.

1	25th	September,	1903	Godhra, Panch Mahals.	Hoppers.
2	28th	,,	,,	Ahmedabad.	Locusts came from Amnagar.
3		October,	,,	Godhra, Panch Mahals.	Locusts.
4	2nd	,,	,,	Kaira.	Locust swarms.
5	3rd	,,	,,	Panch Mahals.	Locust swarms.
6	17th	,,	,,	Panch Mahals.	Locust swarms.
7	20th	,,	,,	Amalner, Khandeish	
8	25th	,,	,,	Yawal, Khandeish.	Eggs laid in May, by swarm from South.
9	26th	,,	,,	Bassein, Thana.	Also in October, 1902.
10	29th	,,	,,	Mandvi, Surat.	
11	2nd	November,	,,	Dholka, Ahmedabad.	
12	,,	,,	,,	Umargaon, Thana.	
13	10th	,,	,,	Bassein, Thana.	Went away.
14	11th	,,	,,	Raver, Khandeish.	Swarm produced from eggs laid in Bhusaval in June. Also came in 1901 and 1902.
15	11th	,,	,,	Mandvi, Surat.	Went to the South.
16	12th	,,	,,	Bulsar, Surat.	Swarm from the North.
17	14th	,,	,,	Chikhli, Surat.	Small swarms passing through.
18	28th	,,	,,	Bulsar, Surat.	Small swarms passing through.
19	28th	,,	,,	Salsette, Thana.	Passed through. Also in 1902.
20	1st	December,	,,	Jambusar, Broach.	Passed through.
21	12th	,,	,,	Belgaum.	
22	13th	January,	1904	Kolaba.	
23	13th	,,	,,	Pen, Kolaba.	
24	15th	,,	,,	Karjat.	
25	15th	,,	,,	Nagotna, Kolaba.	
26	20th	,,	,,	Murbad, Thana.	From Karjat to Kalyan and Shahpur.
27	20th	,,	,,	Roha, Kolaba.	
28	25th	,,	,,	Karjat, Kolaba.	
29	7th	March,	,,	Mahableshwar.	For weeks past.
30	,,	,,	,,	Poona.	
31	13th	,,	,,	Mokhada, Thana.	

32	22nd	March	1904	Khed, Ratnagiri.	
33	25th	,,	,,	Guhagar, Ratnagiri.	Swarm appeared.
34	27th	,,	,,	Thana.	Moving North to South.
35	28th	,,	,,	Fadgam, Ratnagiri.	
36	28th	,,	,,	Ratnagiri.	
37	28th	,,	,,	Salsette, Thana.	
38	29th	,,	,,	Dahanu, Thana.	
39	29th	,,	,,	Dapoli, Ratnagiri.	
40	29th	,,	,,	Mandangad, Ratnagiri.	Moving South-West.
41	31st	,,	,,	Shahapur, Thana.	Moving about since January.
42	31st	,,	,,	Murbad, Thana.	Came from Karjat and Junnar.
43	31st	,,	,,	Vada, Thana.	Moving North-West.
44	31st	,,	,,	Rajapur, Ratnagiri.	
45	1st	April	,,	Sangameshwar, Ratn.	
46	2nd	,,	,,	Bhiwandi, Thana.	Moving into Shahapur, Vada and Bassein.
47	4th	,,	,,	Ratnagiri.	
48	5th	,,	,,	Bassein, Thana.	Went to Mahim.
49	5th	,,	,,	Deogarh, Ratnagiri.	
50	8th	,,	,,	Umargaon, Thana.	Moved Northwards.
51	8th	,,	,,	Sangameshwar, Ratn.	
52	9th	,,	,,	Mahim, Thana.	Came from Bassein.
53	10th	,,	,,	Dahanu, Thana.	
54	11th	,,	,,	Chiplun, Ratn.	
55	11th	,,	,,	Rajapur, Ratn.	
56	11th	,,	,,	Ratnagiri.	
57	13th	,,	,,	Mahim, Thana.	
58	15th	,,	,,	Sangameshwar, Ratn.	
59	16th	,,	,,	Ratnagiri.	
60	19th	,,	,,	Dapoli, Ratnagiri.	
61	20th	,,	,,	Goa.	Appeared in 1901.
62	25th	,,	,,	Chiplun, Ratn.	
63	26th	,,	,,	Sangameshwar, Ratn.	
64	28th	,,	,,	Shahapur, Thana.	
65	28th	,,	,,	Bhimadi.	
66	29th	,,	,,	Rajpipla.	
67	2nd	May	,,	Ratnagiri.	
68	4th	,,	,,	Sangameshwar, Ratn.	
69	6th	,,	,,	Mandangarh, Ratn.	
70	7th	,,	,,	Shahapur, Thana.	
71	9th	,,	,,	Ratnagiri.	
72	9th	,,	,,	Umargaon, Thana.	
73	16th	,,	,,	Ratnagiri.	
74	18th	,,	,,	Jummar, Poona.	
75	18th	,,	,,	Chiplun, Ratn.	
76	19th	,,	,,	Shahapur, Thana.	
77	23rd	,,	,,	Junnar, Poona.	Remained here.
78	25th	,,	,,	Ratnagiri.	

79	27th	May	1904	Shahapur, Thana.	Remained here.
80	28th	„	„	Rajpipla.	Swarms from Mehwas, Khandeish.
81	6th	June	„	Murbad, Thana.	Remained here.
82	7th	„	„	Chota Udaipur.	Locusts appeared.
83	1st	August	„	Mandvi, Surat.	Locusts appeared.

Central Provinces and Berar.

1	22nd	June	1904	Buldana.	Immature, both sexes.
2	22nd	„	„	Amraoti.	Mature, both sexes.
3	24th	„	„	Basim.	
4	25th	„	„	Yeotmal.	Mature, both sexes.
5	28th	„	„	Akola.	Mature, both sexes.
6	29th	„	„	Ellichpur.	Coupling, both sexes
7	8th	July	„	Buldana.	Mature, both sexes.
8	14th	„	,	Akola.	Mature, both sexes, some laid eggs
9	21st	„	„	Betul.	Mature, both sexes.
10	22nd	„	„	Chindwara.	Mature, both sexes.
11	1st	August	„	Basim	g s and hoppers.

LIST OF PLATES.

PLATE I.—Frontispiece. The Bombay Locust.

PLATE II.—Area infested in 1903-1904. The lightly shaded part in the North is the area from which the swarms emerged. The darkly shaded part is the area infested during the third period. The dotted line marks the approximate limits of the area covered during the fifth and sixth periods. Drawn by Hormusji Deboo.

PLATE III.—Reproductive system.

Fig. 1.—Diagram of abdomen of female locust—

(*a*) Alimentary canal; rectum.
(*b*) Genital aperture.
(*c*) Nerve ganglion.

The sebific gland is below the rectum.

Fig. 2.—External reproductive organs, closed.
„ 3.— „ „ „ open.
„ 4.—The digging processes fully expanded.
„ 5.—Alimentary canal, showing cæca.
„ 6.—Ovary and sebific gland.
„ 7.—Diagram of abdomen of male locust showing position of testis behind the cæca.
Fig. 8.—Male reproductive system.
„ 9.— „ „ „

(*a*) Alimentary canal.
(*b*) Genital opening.

„ 10.—Portion of testis showing tubercles opening into vas deferens.

PLATE IV.—

Fig. 1.—Egg mass in the soil. x1.
„ 2.—Egg mass. x1.
„ 3.—Hopper, one day after hatching. x5.
„ 4.—Hopper, after first moult. x5.
„ 5.—Hopper, after second moult. x5.
„ 6.—Hopper, after third moult. x5.
„ 7.—Hopper, after fourth moult. x3.

PLATE V.—

Fig. 1.—Hopper, after fifth moult. x2.
„ 2.—Hopper, after sixth moult. x2.
„ 3.—Newly emerged locust. x1.

PLATE VI.—

Fig. 1.—Bag with vertical bamboos.
„ 2.—Collapsing bag with four bamboos.
„ 3.—The small bag without frame.

PLATE VII.—

Fig. 1.—Bag with bamboos ready for use.
„ 2.—Bamboo frame ready for bag.

PLATE VIII.—

Fig. 1.—Acridium succinctum. Linn
„ 2.— „ peregrinum. Oliv
„ 3.— „ æruginosum. Burm.
„ 4.—Hieroglyphus furcifer. Serv.

PLATE IX—

Fig. 1.—Acridium succinctum. Linn.
„ 2.— „ peregrinum. Oliv.
„ 3.— „ æruginosum. Burm.
„ 4.—Locust in cylinder, for sending through post.

PLATE X.—

Fig. 1.—Acridium succinctum. L. male.
„ 2.— „ „ female.
„ 3.— „ peregrinum. Ol. male,
„ 4.— „ „ female.
„ 5.— „ æruginosum. Burm. male.
„ 6.— „ „ female.
„ 7.—Hieroglyphus furcifer. Serv. male.
„ 8.— „ „ female.

PLATE XI—

Fig. 1-3.—Hoppers of *Acridium æruginosum*. Burm. x1
„ 4.—The painted grasshopper, *Pœcilocerus pictus*. F.

PLATE XII.—

Fig. 1.—Demodocus robustus.
„ 2.—*Acrida turrita*. Linn.
„ 3.—*Acridium melanocorne*. Serv.

PLATE XIII.—

Fig. 1.—Cage.
„ 2.—Hinged sides.
„ 3.—Batten top.

THE MORE IMPORTANT INSECTS INJURIOUS TO INDIAN AGRICULTURE.

By H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,
Imperial Entomologist.

INTRODUCTION.

In the following pages, the insects known to be injurious to crops in India, are described briefly in systematic order. No list of injurious insects exists at present, and this list is published with a view to fixing definitely the nomenclature and status of such pests as have already been described and giving such details as are of value to working Entomologists. There are, unfortunately, several species of major importance, which cannot be included as their generic or specific denomination is not known. These will be included in the next list. New pests will certainly also be found, but this list is complete enough to be of value to working Entomologists interested in economically important species, especially those of the tropics. To those who study the insect pests of the tropics or of almost any locality outside Europe and the United States, it is a matter of regret that there is so little information as to what insects are destructive in these countries. Information about them has to be sought in numerous reports, bulletins and articles, and it is no easy matter to find in what countries a particular species occurs as a pest and what its habits and status there are. This memoir is published to supply this information about India and to give a useful basis for future work. It is proposed to publish a supplementary list when the material is available.

Nomenclature.—I have given the most accurate designation afforded by the literature at my command. That these

designations will not remain accurate will be evident to those who have observed the changes made, for instance, by Sir George Hampson in his new catalogue of the *Noctuidæ*. The literature references indicate the original description wherever possible, the relevant passages in the volumes of the Fauna of India and other literature in India, such as Indian Museum Notes.

Distribution.—I am indebted to Lieut-Colonel Alcock, C.I.E., I.M.S., F.R.S., Superintendent of the Indian Museum, for permission to compile the information showing the localities from which specimens in the Museum were obtained, the work being done by Mr. C. A. Paiva. I have not stated localities in detail, but have given the distribution as I believe it to be from all the records at my disposal, including the Pusa collections and the available literature. In India, there is a fairly sharp distinction between the Fauna of the plains proper and that of the hills (2,500 feet and upwards). This distinction is a very real one to those who have worked at insects in India ; for each species that has been described from the plains, there are probably ten described from the hills ; but in this case species of economic importance are usually "plains species," in some cases common to both hill and plain localities. Where the distribution is given as common in the plains, this does not necessarily mean that the insect will be found in every locality but in any locality in the plains where its food plant is cultivated. Species known to be confined to particular tracts are expressly stated to be so, and in some instances a species, though widely spread, has not been found as a *pest* everywhere in India where it occurs as a normal member of the fauna. Where data are insufficient, I have preferred to assume the wide distribution rather than to state that the insect is restricted to a particular tract.

Biology.—This information is a summary of the most important facts. Every working economic Entomologist gets a definite idea of each important species and tries to fix its biological characteristics ; I have simply put down the mental picture I form of each species derived from numerous observations and reports. The information about hibernation is equally a very

careful summary of such facts as are known. It will probably be some time before we can generalize about the influence of climate, etc., on the activities of insects in India. As a general rule, in most parts of India, there are three more or less well-defined seasons in the plains ; the cold months (November 15th to March 15th), the hot dry months (March 15th to June 15th), the rainy months and succeeding hot moist weather (June 15th to November 15th). The relative duration of these periods varies greatly in different parts ; in the Punjab the cold weather is long and more intense, the hot weather lasts until well into July when the rains break, and the rains may be scanty. In localities below the East and West Ghauts, in Lower Bengal, Eastern Bengal and the valleys of Assam, the cold weather is less intense, the succeeding months are far more moist than elsewhere, and the period of moist warm weather is very much longer. The activities of insects are in this latter case of longer duration, and hibernation may be unknown. The facts then are best expressed by a reference to these three seasons, the cold weather, the hot dry weather, the warm moist rainy months. No attempt is made to discuss the hibernation of these species in the hills.

It is impossible to avoid a reference here to the fascinating subject of insect life zones in India : could we map the various life zones for insects, as is done for instance for plants, we could give the distribution and habits of insects according to such zones. Unfortunately the information necessary to map such zones is not forthcoming as yet, and it must be long before we can hope to be in a position to commence such an enquiry. We may perhaps draw attention to the very generally uniform conditions that prevail over the great cultivated areas. Though the extremes are very distinct, the warm moist rice areas shade into the colder dry wheat areas ; the crops are well distributed over a great part of the cultivated areas of India, and the biological distinctions between distinct areas is far less marked if we consider only our pests than if we consider insect life as a whole. At a later date it may be possible to discuss insect life zones in general : if we bear in mind the inevitable differences in the behaviour of a pest due to varying

conditions of moisture, heat, etc., we can apply the facts given below to the great majority of the areas in which crops are cultivated.

Food Plants.—The known cultivated foodplants, as well as wild ones, are enumerated: much has yet to be learnt under this head.

Status.—This section is the most difficult to express and the views adopted would possibly not be endorsed by other Entomologists in India. They sum up the total of my experience from personal observation, from the work of assistants, and from specimens sent in from all parts of India. With so enormous an area to consider and with so little information from other observers, it is inevitable that I should state my personal ideas of the importance of each species; these ideas automatically adjust themselves to fresh facts, and in further years of work, the views now expressed will doubtless undergo much modification. I believe they are in the main near to the truth.

This memoir was compiled originally as a working basis at the time that I wrote "Indian Insect Pests," and is published as an adjunct to that volume. I have freely used all the records at my disposal, and it is not possible to acknowledge them in detail. The work of Ratiram Khamparia, Entomological assistant, in the Department of Agriculture, Central Provinces, and of Lala Vishwanath Sahai, Entomological assistant in the Department of Agriculture, Punjab, have been included; my staff has also been able to supplement my records. I owe much to the specimens sent in at the instance of the Directors of Agriculture of all Provinces by District officers, Farm Superintendents and officers of the Departments of Agriculture. My thanks are especially due to those Entomologists in Europe and elsewhere who have liberally given their time to the identification of insects, which offer few points of interest, not being new or rare. Mons. Desneux has very kindly examined the termite; the specimens of Coleoptera sent me by Mr. H. E. Andrewes, have enabled me to correct the nomenclature of some species apparently wrongly identified in Indian Museum Notes; Mr. E. Meyrick has

examined the Pterophoridæ and Tineidæ, describing the new species ; Mons. Schouteden very kindly worked over the Aphides.

It is proposed to issue correction slips as the revision of Indian groups alters the nomenclature here employed ; an isolated worker in a far country is largely dependent on the periodical revisions of the many groups of insects included in this list. Corrections must be numerous and, as work progresses, additions must be made to this list. For the convenience of Indian students a list of the more important insects, chiefly Curculionidæ and Diptera, whose identification is at present impossible, has been printed separately : I hope to include these in a supplementary list at no very distant date, but as the completion of this catalogue would entail its indefinite postponement until the last new pest had been identified, I prefer to publish this incomplete one as a commencement.

H. MAXWELL-LEFROY.

ACRIDIIDÆ.

67. CHROTOGONUS TRACHYPTERUS.—Blanch., Ann. Soc. Ent. Fr. V. 607.

Indian Museum Notes, I—V (Fig. i*).
Indian Insect Pests, p. 220 (Fig. i).

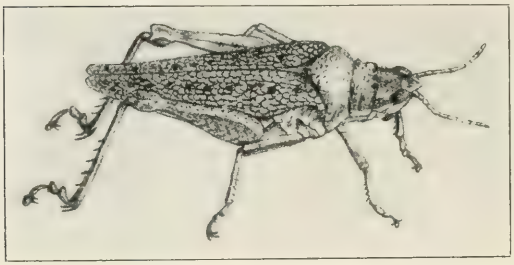


FIG. 1. CHROTOGONUS TRACHYPTERUS. ×2.

Male 13 m. m. Female 19 m. m. (Vertex to pygidium.) Flattened, the dorsal surface and tegmina roughened and earth colour. A variable species; the destructive individuals are probably all of this species, though it is uncertain how many species are common in the plains.

Distribution.—The plains and lower slopes of the hills.

Biology.—Eggs in clusters in soil. Nymphs and imago on soil, in fallow fields, in newly-sown land, in waste land. No definite hibernation, development checked in cold weather, broods irregular. Found throughout the year.

Food Plants.—Young indigo, opium, lucerne, cotton, bhinda, groundnut, castor, tobacco.

Status.—A major pest, responsible for much loss in young crops. General and of irregular occurrence, influenced by climatic conditions.

---

* The following contractions are used to denote figures :—
e = egg, l larva, n = nymph, p = pupa, i = imago. [H. M. L.]

ACRIDIIDÆ—(*contd.*)

186. ATRACTOMORPHA CRENULATA.—Fabr.,
Indian Museum Notes, III, p. 21.

FIG. 2. ATRACTOMORPHA CRENULATA.

Male, 24—27 m. m. Female, 32—35 m. m. (frons to wing apex). Colour green, stippled lighter. Lower wings pink. Face looking down, prosternum laminate, antennæ not flattened.

Distribution.—Hills and plains, probably universal. Ceylon, Burma, Java.

Biology.—Eggs in soil in clusters. Nymphs and imago on dry soil in fallow fields, young crops and waste lands. No hibernation, development checked in colder localities. Broods irregular, found throughout the year.

Food Plants.—Tobacco seedlings, *Compositæ.*

Status.—A major pest, responsible for much loss in young crops. General and of regular occurrence.

ACRIDIIDÆ—(*contd.*)

47. HIEROGLYPHUS FURCIFER.—Serv. *Orth.*, p. 677.
Indian Museum Notes, II, p. 30 (Fig. i.)
Indian Insect Pests, p. 119 (Fig. e. i.).

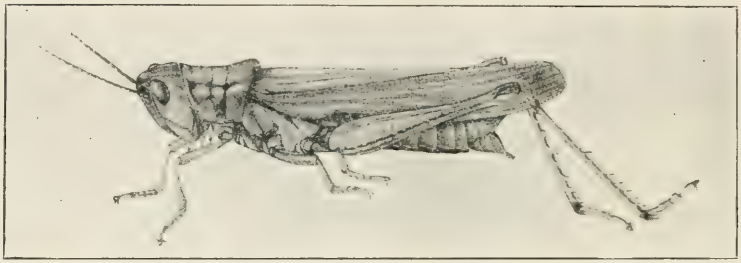


FIG. 3. HIEROGLYPHUS FURCIFER. NORMAL FORM.

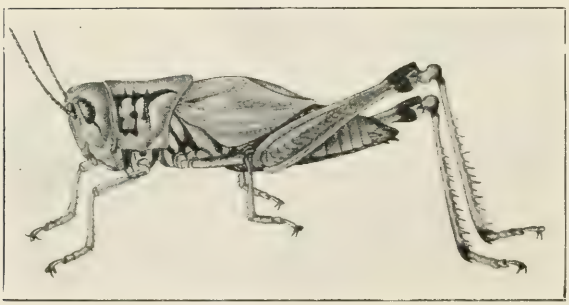


FIG. 4. HIEROGLYPHUS FURCIFER. MICROPTEROUS FORM.

Male, 23—36 m. m. Female, 36—50 m. m. (frons to pygipium). Green or dry grass colour. Indented black lines on the prothorax, no other markings. Hind tibiæ blue.

A micropterous form occurs commonly with intermediates to the macropterous form.

Distribution.—In suitable localities in Bengal, the United Provinces, Central Provinces, Mysore, Hyderabad, the Bombay Presidency and Madras, Burma (Bhamo).

Biology.—Egg mass in soil, November to June. Nymphs and adults in wet vegetation in rains. One brood annually.

Food Plants.—Grasses, *rice*, cane, small millets.

Status.—Major local pest, of regular occurrence.

ACRIDIIDÆ—(*contd.*)

46. ACRIDIUM SUCCINCTUM.—Linn. Cent. Ins., p. 15.
Indian Museum Notes, I—V (Fig. i.).
Indian Insect Pests, p. 214 (Fig. e. n. i.).
Memoir, Agricultural Department, Ent. I (Fig. e. n. i.).

FIG. 5. ACRIDIUM SUCCINCTUM.

Male, 59—68 m. m. Female, 74—80 m. m. (frons to wing apex). Colour variable ; lower wing red. Tegmen lightly marked in fuscous, thorax narrow and scarcely indented ; never unicolorous, prothorax and tegmen striped.

Distribution.—From Gujarat to Kanara on the West Coast, to Bengal, Assam and Burma, in forest areas. Principally in forests of Kanara, Goa, and the Western Ghauts.

Biology.—Eggs laid in soil in clusters, at first burst of monsoon. Nymphs during rains, imago flying October-November to June.

Food Plants.—Grasses, grain crops, forest trees, palms.

Status.—Occasional major pest, local and infrequent.

ACRIDIIDÆ—(*concld.*)

66. ACRIDIUM (SCHISTOCERCA) PEREGRINUM.—Oliv.
Voy. Empire Ottoman, II, p. 224.
Indian Museum Notes, I—V (Fig. i).
Indian Insect Pests, p. 214 (Figs. e. n. i.).
Memoir, Agricultural Department, Ent.1 (Fig. i).

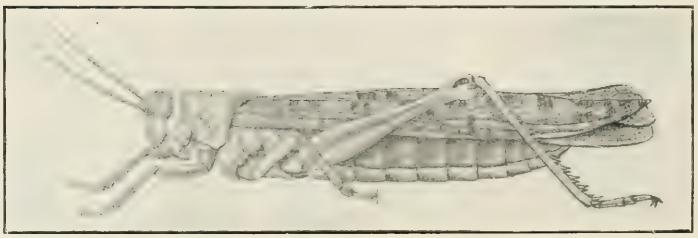


FIG. 6. ACRIDIUM PEREGRINUM.

Male, 62—65 m. m. Female, 62—78 m. m. (frons to wing apex). Unicolorous, yellow, pink or purple-red, black speckled. Tegmen spotted in many black speckles. No longitudinal bands of colour. Prothorax narrow, transversely indented.

Distribution.—Northern India, Baluchistan to Himalayas and Bengal, Arabia, Persia, Cyprus, Algeria, Egypt. Stated to originate in South America.

Biology.—Eggs in clusters in dry soil or sand. Nymphs in armies moving. Imago flies in swarms. Two broods yearly of varying date.

Food Plants.—Crops and trees.

Status.—Major pest, local and of irregular occurrence.

GRYLLIDÆ.

51. Brachytrypes achatinus.—Stoll. Spect. Gryll. Achet., p. 4.

Indian Museum Notes III, 4-45 (Fig. i.).
Indian Insect Pests, p. 224 (Fig. i.).

Fig. 7. Brachytrypes achatinus.

31—43 m. m. (frons to pygidium).

Uniform deep brown.

Distribution.—In hills, plains near Himalayas, Burma, all Eastern Asia.

Biology.—Subterranean, imago rarely on surface. Found throughout the year.

Food Plants.—Weeds, lucerne, indigo, tobacco.

Status.—Minor local pest, destructive to young crops and to tobacco.

GRYLLIDÆ—(*concld.*)

260. GRYLLOTALPA AFRICANA. Pal. B. Insect rec en Afrique et en Amer., p. 229 (1805).
Indian Insect Pests, p. 224 (Fig. i).

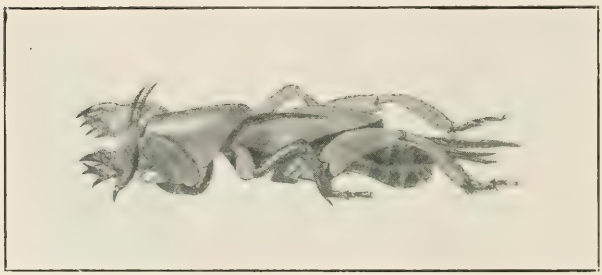


FIG. 8. GRYLLOTALPA AFRICANA.

22—25 m. m. (frons to wing apex). Deep brown to black. Digging leg without tubercle (cf. *G. vulgaris*).

Distribution.—Africa, New Holland, and throughout tropical Asia. (The Himalayan species is the palæarctic *G. vulgaris.*)

Biology.—In deep burrows in soil. Imago flies at night. Hibernation uncertain.

Food Plants.—Probably carnivorous, injuring crops by its burrowing. (Indigo, fruit trees, tree cottons, tobacco.)

Status.—Minor local pest.

LOCUSTIDÆ.

170. Schizodactylus monstrosus.—Drury. Ill. Exot. Ent. II. Pl. 43, Fig. 1.
Indian Museum Notes, I—III (Fig. i).
Indian Insect Pests, p. 224 (Fig. i).

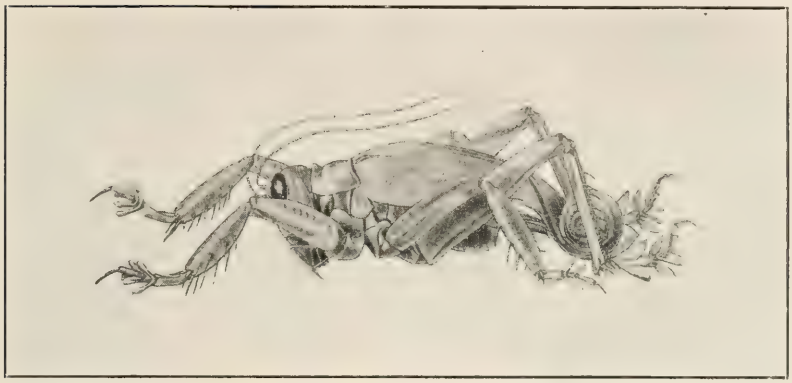


Fig. 9. Schizodactylus monstrosus.

41—52 m. m. (frons to apex of wing). The tegmina spirally rolled at the apex, the tarsi with flat expansions.

Distribution.—Behar generally. Sambalpur, Duars, Goalpara, Sibsagar, Sikkim, Lucknow, Allahabad, Karachi, Nilgiris, Nuddea, Murshidabad, Mirzapur, Krishnagar, Multan, Baluchistan, Persian Frontier.

Biology.—In very deep burrows in sandy or loamy soil. Hibernation uncertain. Imago can fly, but is rarely found above soil.

Food Plants.—Probably a carnivorous insect that rarely eats vegetable matter. (Injures fruit trees and tobacco.)

Status.—Local pest, serious in a few localities.

NEUROPTERA.

(TERMITIDÆ.)

198. TERMES OBESUS.—Ramb., Hist. Nat. Neur., p. 304 (1842).

T. *taprobanes*. Indian Museum Notes, III—V. (Figs. n. i.).

„ „ Indian Insect Pests, p. 228 (Figs. n. i.).

FIG. 10. TERMES OBESUS. WINGED QUEEN.

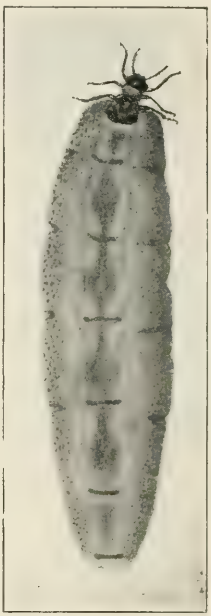


FIG. 11. TERMES OBESUS. WINGLESS EGG-LAYING QUEEN.

The common "White-ant" of the Plains.

Distribution.—India, common throughout the Ganges Valley, Cuttack, Nagpur, Bombay Presidency, Madras.

Biology.—Subterranean, and making mounds at the surface. Winged forms appear only at definite times in the rains. Active throughout the year.

Food Plants.—Timber trees, cane, wheat, groundnut, sunflower, mango, oats, safflower, juar, strawberry, khorasani, moth.

Status.—Major pest of general occurrence.

TENTHREDINIDÆ.

54. ATHALIA PROXIMA.—Klug. Mag. Ges. Naturf. Bul., Vol. 7, p. 130.

Indian Insect Pests, p. 152.

The only known destructive sawfly in the plains. 6 m. m. (frons to pygidium). Head, meso and meta-notum black. Pronotum, abdomen, shining orange. Wings smoky hyaline, nervures black.

Distribution.—India, Calcutta, Behar, Cawnpore, Lahore, Nagpur, Poona, Surat, Baroda, Assam Valley.

Biology.—Egg in tissue of margin of leaf. Larva on the plants, hiding in soil by day. Pupa in light cocoon between two leaves, or in soil. Imago day flying. Active in cold weather only, usually passing the hot weather and rains as a resting larva, in an earthen cocoon.

Food Plants.—Field and garden *Cruciferæ.*

Status.—Minor pest, rarely injurious.

FORMICIDÆ.

221. DORYLUS ORIENTALIS.—Westw. P. T. S., V., p. 72. Bingh. F. Ind., Hym. II, p. 4. Indian Insect Pests, p. 231 (Fig. worker).

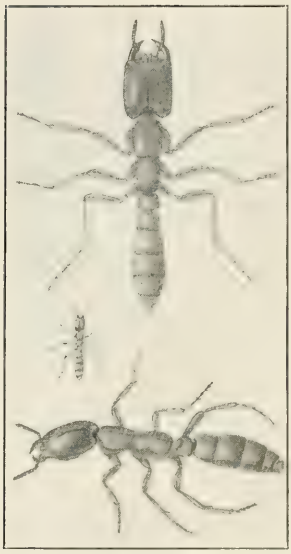


FIG. 12.
DORYLUS ORIENTALIS WORKERS.

Worker, brownish-yellow, pedicel one jointed, eyes absent, antennæ nine jointed. 2·5—3, 5—6 m. m. *Male*, a large wasp-like insect ; second joint of flagellum beneath not pubescent, 17—23 m.m.

Distribution.—Malay Peninsula, Borneo, Java ; throughout India, Burma and Ceylon.

Biology.—In nests below ground ; come up to surface as termites do. Males fly at night. Females unknown.

Food Plants.—Vegetable crops.

Status.—Sporadic local pest of vegetable gardens.

FORMICIDÆ—(*concld.*)

262. HOLCOMYRMEX SCABRICEPS.—Mayr. Verh. Zool-bot, Ges. Wien. XXVIII, p. 672.
Bingham, F. Ind. Hym. II, p. 282.
Rothney, Tr. Ent. Soc., London, 1889, p. 367 (habits).
Indian Insect Pests, p. 232.

Worker. Pedicel two-jointed. Antennæ 12-jointed, clypeus bicarinate and bidentate, produced between bases of antennæ; pronotum unarmed; erect hairs simple. Head, thorax and pedicel reddish ferruginous; abdomen dark brown. Head finely striate, abdomen smooth. 3·5—7 m. m.

Distribution.—Punjab and Bengal. Irregularly throughout India. (Bingham.)

Biology.—In nests close to the surface of the soil.

Food Plants.—Seeds of grass, rice and kangni.

Status.—Minor pest.

SCARABAEIDÆ (Dynastides).

126. Oryctes rhinoceros.—Linn.

Indian Museum Notes, II, III, V (Fig. i).
Indian Insect Pests, p. 207 (Fig. i).

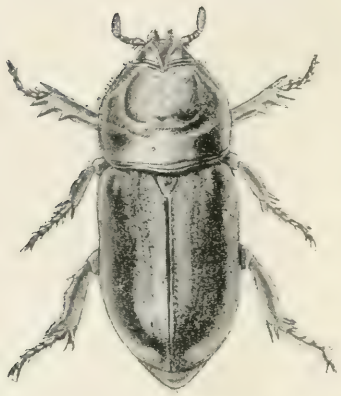


Fig. 13.
Oryctes rhinoceros. Male.

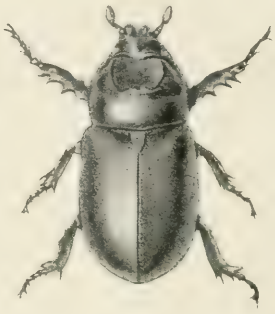


Fig. 14.
Oryctes rhinoceros.
Female.

Male, 43 m. m. (apex of mandible to pygidium). A single backwardly curved horn on head, two teeth on prothorax at rim of a hexagonal depression. Elytra punctate and faintly striate. Colour black above, deep brown below, with ferruginous to deep brown hair.

Female. Similar but smaller, horn reduced to a tubercle, depression less marked.

Distribution.—India, Burma, Ceylon, Straits Settlements.

Biology.—Larva and pupa in manure heaps and decaying woody matter. Imago flying at night, length of life-history unknown, probably one year.

Food Plants.—Palms, injured by the imago.

Status.—Sporadic minor pest.

SCARABAEIDÆ (Cetoniides).

264. Chiloloba acuta.—Wied. Zool. Magazine, II, 1, p. 87.
Indian Insect Pests, p. 200.

12—14 m. m. (clypeus to apex of elytra). Bright metallic green, finely pilose above, with tufts of white hair below.

Distribution.—Wardha, Nagpur (R. R. K.), Kanara (Bell coll.), Dehra Dun, Chupra. Probably widespread in India.

Biology.—Imago appears yearly. The life-history is unknown and probably occupies one year.

Food plants.—Juari, kutki.

Status.—Local minor pest, injuring the flowers and causing loss of grain.

COCCINELLIDÆ (Epilachnides).

131. Epilachna viginti-octo-punctata.—Fabr.,
Indian Museum Notes, III, 6, p. 9 (Fig. i).
Haymann, Report of Cawnpore Farm, 1903.
Indian Insect Pests, p. 204 (Fig. i).

Fig. 15.
Epilachna viginti-octo-punctata.

7 m. m. (Clypeus to apex of elytra). Colour deep red; above, finely pilose. Fourteen black spots on each elytron. It is uncertain how many species are destructive or whether, as is possible, there is but one destructive species which is variable in colour and spotting.

Distribution.—Throughout the plains of India.

Biology.—Eggs in clusters on plant. Larva feeding openly on plant. Pupa suspended by tail. Imago day feeding. Hibernation as imago. Found in hot weather and rains.

Food Plants.—Brinjal, potatoes and wild *Solanaceæ;* cucurbitaceous plants.

Status.—Minor pest of vegetable crops.

COCCINELLIDÆ—(*contd.*)

28. EPILACHNA DODECASTIGMA.—Muls.,
Indian Museum Notes, IV, p. 2.
Indian Insect Pests, p. 204.

FIG. 16. EPILACHNA DODECASTIGMA.

Larger, six spots on each elytron. Doubtfully distinct from the last.

Distribution.—General in plains.

Biology.—Egg in clusters, larva on plant, leaf-eating. Pupa on plant. Imago leaf-eating. Hibernation as imago.

Food Plants.—Cucurbitaceous plants, brinjal.

Status.—Minor pest of vegetable crops.

BUPRESTIDÆ.

60. SPHENOPTERA GOSSYPII.—Kerr., Ann. Soc. Ent. Belge. 36, p. 195.
Indian Museum Notes, II, p. 33 (Fig. i).
Indian Insect Pests, p. 100 (Fig. l, p. i).
Agric. Journ. India, Vol. I, p. 58 (Fig. l, p. i).

FIG. 17.
SPHENOPTERA GOSSYPII,

FIG. 18.
SPHENOPTERA GOSSYPII.

9 m. m. Sides parallel, head as large as the thorax, eyes prominent. Deep bronzy black above and below. (Smaller than the closely similar species that attacks tur.)

Distribution.—Bombay Presidency, Central Provinces, Punjab, Behar rarely.

Biology.—Larva a stemborer in small woody stems. Pupa in stems. Hibernation in colder localities only. Imago living through hot weather. About four broods from August to January.

Food Plants.—Cotton.

Status.—Local minor pest of cotton, of regular occurrence.

CANTHARIDÆ.

40. CANTHARIS TENUICOLLIS.—Pall. Icon. Ins., p. 92.
? C. ruficollis, Fabr. Syst. El. II, p. 78.
(*Epicauta*). Indian Museum Notes, II, V (Fig. i).
? C. ornata, Cast. Hist. Nat. Coll. II, p. 272.
Indian Insect Pests, p. 205 (Fig. i).

FIG. 19.
CANTHARIS TENUICOLLIS.

12-13 m. m. (occiput to apex of elytra). Head, elytra and abdomen metallic green, prothorax reddish-brown, compressed in front.

Distribution.—Surat, Ratnagiri, Cawnpore, Lahore, Nagpur, Berar, and general in the Central Provinces.

Biology.—Imago appears in September-October in large numbers. Life-history unknown. Imago feeds at night on anthers and pistils of flowers.

Food Plants.—Juari, maize, rice, kutki, and other small millets.

Status.—Local pest of considerable importance.

CANTHARIDÆ—(*contd.*)

39. CANTHARIS ROUXI.—Cast. Hist. Nat. des. Col. II, p. 273.
Indian Museum Notes, II, V (Fig. i).
Indian Insect Pests, p. 205 (Fig. i).

FIG. 20.
CANTHARIS ROUXI.

16—17 m. m. (occiput to apex of elytra). Head reddish-brown, elytra dull brown, thorax black, the whole with short brown pubescence.

Distribution.—Central Provinces, Kanara, Behar.

Biology.—Imago appears in August—October. Life-history unknown; feeds by night on anthers and pistils of flowers.

Food Plants.—Rice, small millets.

Status.—Serious local pest.

CANTHARIDÆ—(*concld.*)

50. MYLABRIS PUSTULATA.—Thunb. Nov. Ins. Spec. Part VI.
? M. Sidæ, Fabr.
? M. Phalerata, Pall.
Indian Museum Notes, I—V (Fig. i).
Indian Insect Pests, p. 205 (Fig. i).

FIG. 21.
MYLABRIS PUSTULATA.

17—25 m. m. (occiput to apex of elytra). Black, with black pubescence. Elytra with two broad bands and an anterior spot of orange. Size and banding very variable. This is a variable species, and it is not certain how far more than one species are concerned. Apparently, one variable species is found throughout the plains and lower hills. The synonymy of this widespread insect is in confusion.

FIG. 22.
MYLABRIS PUSTULATA.

Distribution.—Throughout the plains and lower hills of India ; probably also South Europe, Egypt, China.

Biology.—Imago appears in numbers in August to October feeding by day on flowers. Eggs laid in masses on ground or grasses, larva active. Further history unknown.

Food Plants.—Flowers of malvaceous, cucurbitaceous and leguminous crops and vegetables.

Status.—Minor local pest, sporadic.

CHRYSOMELIDÆ.

(Galerucides.)

11. Aulacophora foveicollis.—Kust. Kaf. Eur. XXVIII, p. 100.

Abdominalis, Indian Museum Notes, I, II, IV (Fig. i). Indian Insect Pests, p. 164, 200 (Fig. i).

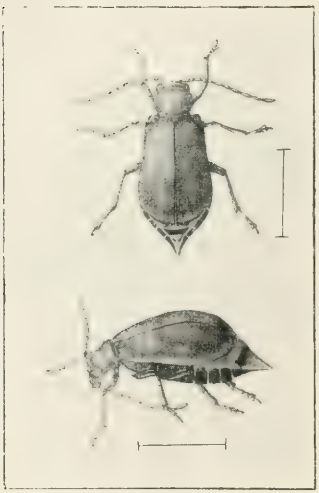


Fig. 23.
Aulacophora foveicollis.

6 m. m. (occiput to apex of elytra). Orange brown; pronotum finely punctured and transversely indented; elytra finely punctured. Black below except prosternum and apical portion of the terminal segment.

Distribution. — Throughout the plains of India.

Biology.—Imago throughout the year on plants. Life-history unknown.

Food Plants.—Cucurbitaceous plants.

Status.—Minor pest of vegetables.

CHRYSOMELIDÆ—(*contd.*)

(HISPIDES.)

41. HISPA AENESCENS. Baly.—Journ. As. Soc. Be. LV, Pt. II, p. 412 (1886).
Indian Museum Notes I, IV, V (Fig. i).
Indian Insect Pests, p. 114 (Fig. i).

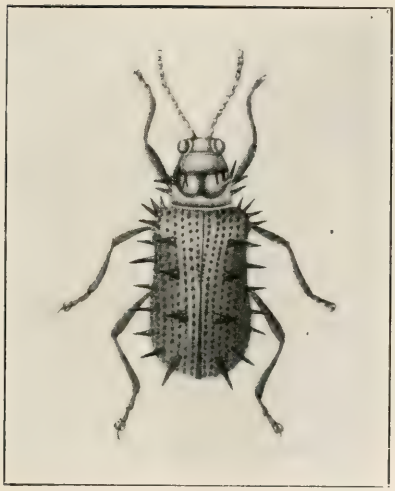


FIG. 24.
HISPA AENESCENS.

5 m. m. (occiput to apex of elytra). Steel blue to black. A single four branched spine (almost four single spines from one base) at each side in front and a single spine at each side behind, on the prothorax, which is otherwise unspined. Elytra spined.

Distribution.—Assam, Burma, Bengal, Malabar, Kulu.

Biology.—Eggs laid in leaf, larva mining in leaf, pupa in leaf, imago flying, leaf-eating. Hibernation as imago, breeds chiefly in rains.

Food Plants.—Rice, grasses.

Status.—Major pest, local and sporadic.

HISPIDES—(*contd.*)

124. LEPTISPA PYGMÆA.—Baly. Cat. of Hisp. 1858, p. 2. Indian Museum Notes, III, IV, V (Fig. i). Indian Insect Pests, p. 201 (Fig. i).

FIG. 25. LEPTISPA PYGMÆA.

Length 4 m. m. Narrow, sides nearly parallel, steel-blue, thorax and elytra punctured ; no spines.

Distribution.—Poona, Malabar, Ceylon.

Biology.—Imago on leaves ; life-history unknown.

Food Plants.—Rice and cane.

Status.—Local pest, with *Hispa aenescens.*

CERAMBYCIDÆ.

32. XYLOTRECHUS QUADRIPES.—Chevr. Mem. Soc. Sci. Liege, XVII, p. 63.
Dunning, Coffee Borer, Trans. Ent. Soc., 1868.
Taylor, White Borer, 1868, Madras.
Bidie, Ravages of Borer, 1869, Madras.
Gahan, F. Ind. Col. I, p. 245 (Fig. i).
Indian Museum Notes, III, IV (Fig. i).

FIG. 26. XYLOTRECHUS QUADRIPES.

Length 15 m. m. Black, abdomen banded in white : white or light yellow markings on elytra. Legs black, hind femora almost wholly red.

Distribution.—Coffee districts of South India, Assam, Burma, Siam, Tonkin (Gahan).

Biology.—Larva a tree borer. Pupa in bore. Imago emerges at one period, usually October.

Food Plants.—Coffee, (?) bamboo.

Status.—Serious local pest of coffee. The White Borer.

CURCULIONIDÆ.

6. MYLLOCERUS MACULOSUS.—Desb. des Log.
Indian Museum Notes, IV, p. 111 (Fig. i).
Indian Insect Pests, p. 112, 202 (Fig. i).

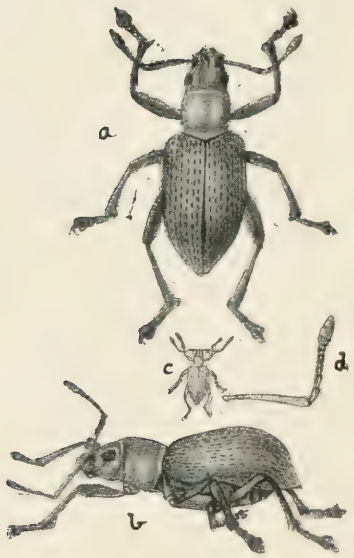


FIG. 27. MYLLOCERUS MACULOSUS.

Length 8—9 m. m. Clothed in scales white to light green in colour; the elytra appear punctate in rows owing to the absence of scales on these spots.

Distribution.—Bombay Presidency, Central Provinces, Punjab, Bengal, Cawnpore, Madras.

Biology.—Imago a leaf-eating weevil. Life-history unknown. Found throughout the year.

Food Plants.—Cotton, indigo, tur, maize, china.

Status.—Minor pest.

Curculionidæ—(*contd.*)

78. Tanymecus Indicus.—Fst.

Indian Museum Notes, III, IV (Fig. i).
Indian Insect Pests, p. 221 (Fig. i).

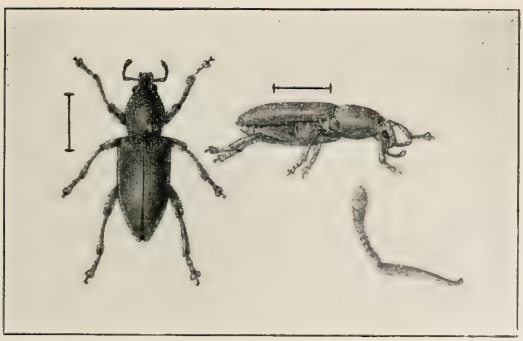


Fig. 28. Tanymecus Indicus.

4—6 m. m. Dark brown, clothed in light brown scales. Longitudinal lines on elytra.

Distribution.—Plains of Punjab, United Provinces, Behar.

Biology.—Imago found in June and November on soil. Life-history unknown. Hibernation uncertain.

Food Plants.—Wheat, gram, mangel wurzel, opium, juar, sunflower, cotton, maize.

Status.—Sporadic pest, locally important.

CURCULIONIDÆ—(*contd.*)

7. CYLAS FORMICARIUS.—Fabr. Ent. Syst. II, p. 549.
(*C. Turcipennis.*) Schh. Gen. et. Sp. Curc., I, p. 369.
Tryon. Queensl. Agric Journ., 1900, p. 176.
Indian Insect Pests, p. 162 (Fig, i).

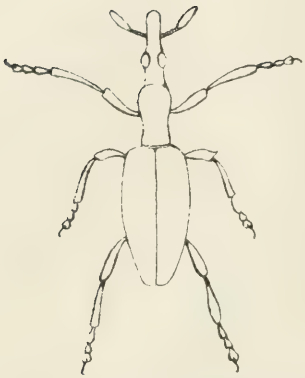


FIG. 29. CYLAS FORMICARIUS.
(From Tryon).

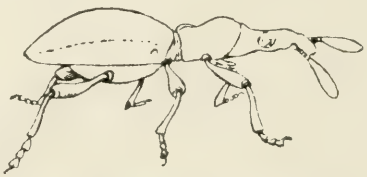


FIG. 30. CYLAS FORMICARIUS.
(From Tryon.)

6 m. m. (apex of rostrum to pygidium). Head, abdomen and elytra dark steel-blue; prothorax and antennæ reddish-brown; legs red except dilated femora which are black. Female has shorter, thicker antennal club.

Distribution.—Throughout the tropical and subtropical regions. Australia. In India, Poona, Madras, Surat, Pusa, Nagpur; probably widespread in the plains.

Biology.—Larva boring in tubers and succulent stems. Imago flies. Hibernation uncertain.

Food Plants.—Sweet potato.

Status.—Minor pest, sporadic and occasionally injurious.

CURCULIONIDÆ—(*contd.*)

204. CRYPTORHYNCHUS FRIGIDUS.—Schonh.

C. mangiferæ, Indian Museum Notes, I (Figs. l. p. i.).
„ Indian Insect Pests, p. 174.
„ Agric. Journ. India, I, p. 164 (Fig. i).

FIG. 31.
CRYPTORHYNCHUS FRIGIDUS.

7 m. m. Prothorax rugose, elytra coarsely punctured in lines. Dark-brown to black.

Distribution.—Assam, Bengal, United Provinces, Satara, Bombay. [Natal (Fuller), Hawaii (Kotinsky), are *C. mangiferæ*, Fabr.]

Biology.—Larva a borer in fleshy fruits. Pupa in bore. Imago long-lived, remaining torpid from August to May. One brood yearly in the plains.

Food Plant.—Mango.

Status.—Sporadic pest of regular occurrence.

CURCULIONIDÆ—(*concld.*)

141. RHYNCHOPHORUS SIGNATICOLLIS.—Chevr. Ann. Soc. Ent. Fr. 6, ii, p. 562 (1882).

R. ferrugineus Ol. Indian Museum Notes, II (Figs. l. p. i).

„ Indian Insect Pests, p. 208 (Figs. p. and i).

FIG. 32. RHYNCHOPHORUS SIGNATICOLLIS; imago and cocoon.

Length 34—36 m.m. (apex of rostrum to pygidium). Deep ferruginous brown, prothorax with black markings, elytra with longitudinal incised lines. Male rostrum shorter, with pilose pad on dorsal surface.

Distribution.—India, Ceylon, Burma, Straits Settlements. In India, general from Baluchistan to Assam and Malabar.

Biology.—Larva a borer in soft tissues as are the Calandrini generally. Pupa in tree in cocoon of twisted fibres. Imago flying at night. Length of life-history unknown.

Food Plants.—Cocoanut and other palms.

Status.—Local sporadic major pest.

NYMPHALIDÆ.

236. MELANITIS ISMENE.—Cram. Pap. Exot. I, pl. 26.
de N. J. A. S. Ben. LV, p. 237, (Fig. l. p).
M. & de N. Butt. Ind. I, p. 256, (Fig. i).
Bingh F. Ind. Butt. I, p. 159 (Fig. i).
Indian Museum Notes, V, p. 137, (Fig. i.)
Indian Insect Pests, p. 122, (Fig. i).

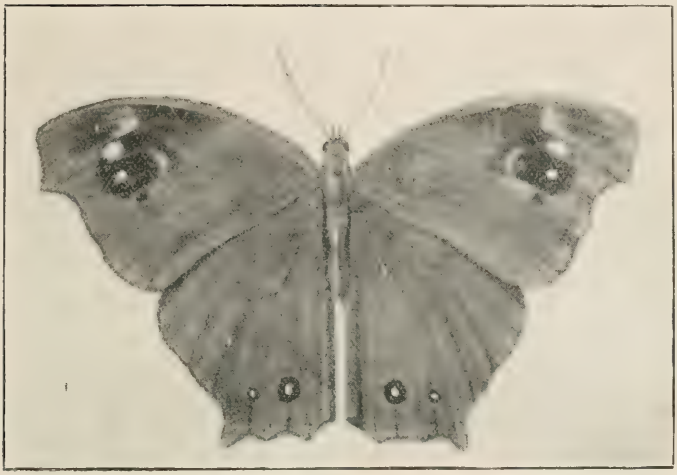


FIG. MELANITIS ISMENE.

Expanse, 70—80 m.m. Brown, forewing with two large subapical black spots, with smaller white spots and an inner ferruginous border. Wet season form has the ferruginous markings smaller. Hindwing with a white-centred ocellus, replaced in wet season form with three or four white spots. Female paler, with more diffused ferruginous markings.

Distribution.—Africa, Madagascar, Mauritius, Bourbon. Indo-Malayan region to Australia. In India, common in Bengal, Central and Peninsular India ; also in Assam, Burma, Ceylon, rare in the Punjab and Himalayas, common in United Provinces (de N.).

Biology.—Egg singly on leaf. Larva on leaves, protectively coloured ; nocturnal. Pupa on plant. Imago, lower side of wings cryptically coloured to resemble dead leaf. Imago has a habit of flying round the roots of trees, under dense shade. Found in rains and later, two broods from June to November, possibly two in dry weather. Imago lives through winter. Dry and wet season form.

Food Plants.—Rice, juari, grasses.

Status.—Minor pest of rice.

Larva.—$1\frac{1}{2}$ inch long, grass green. Two erect processes on head and on anal segment, spiny. Prothorax constricted, abdomen rough and somewhat flattened, with white spots bearing hairs.

NYMPHALIDÆ—(*concld.*)

225. JUNONIA ALMANA.—Linn. Syst. Nat. ed. X, 1758, p. 472.
M. & de N. Butt. Ind. II, p. 68.
Bingh. F. Ind. Butt. I, p. 361.

FIG. JUNONIA ALMANA.

The only Indian Junonia with the ground colour rich orange-yellow. Expanse 54—62 m. m.

Distribution.—China, Japan, Malayan sub-region. In India throughout the plains and up to 6,000 feet. (de N.).

Biology.—Larva a typical leaf-eating caterpillar. Pupa on plant; chiefly found in rains and until November. Two broods from June to November. Dry and wet season form. Imago found throughout the year.

Food Plants.—Rice; principally wild plants.

Status.—An occasional component of swarms of caterpillars in early rains.

Larva.—$1\frac{1}{4}$ inch; cylindrical, deep brown to black. Prothorax black with brown spots, with two pairs of spiny processes; rest of body with a dorsal, and three dorsolateral rows of spiny processes.

LYCÆNIDÆ.

202. CATOCHRYSOPS CNEJUS.—Fabr. Ent. Syst. Suppl., p. 430.
de N. Butt. Ind. III, p. 178.
Bingham. F. Ind. Butterflies II, p. 415.

Expanse 20—30 m. m. Violet blue, the male with two black spots at anal angle of hindwing, female with a broad brown border to both wings. Underside of wings grey, yellow tinged, with brown markings and marginal spots, two of which form ocelli.

Distribution.—China, Australia, South Sea Islands, Indo-Malayan region. In India, throughout the plains.

Biology.—Egg singly on leaf, larva feeding in pod. Pupa on pod. Several broods a year in plains.

Food Plants.—Tur, lobia, mung and *Phaseolus trilobus.*

Status.—Minor general pest.

Larva.—$\frac{1}{2}$ inch, flattened, green or pink, covered with white tubercles.

LYCÆNIDÆ—(*concld.*)

95. VIRACHOLA ISOCRATES.—Fabr. Ent. Syst. III, pt. I., p. 266.
de N. Butt. Ind. III, p. 477.
Indian Museum Notes I, 193, (Fig. 1, p. i).
Indian Insect Pests, p. 179. (Fig. l., p. i).

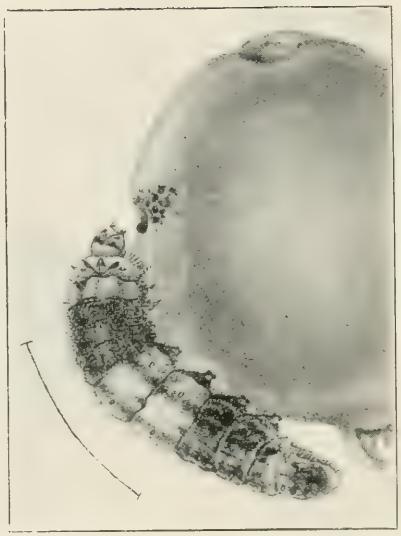


FIG. 35. VIRACHOLA ISOCRATES, larva on pomegranate.

FIG. 36. VIRACHOLA ISOCRATES.

Expanse, 38—45 m. m., 45—50 m. m. Male, upper side deep violet-blue with a gloss; female violet brown.

Distribution.—Common almost everywhere in the plains of India but the desert tracts (de N.).

Biology.—Eggs on calyx of flower. Larva in fruits. Pupa in eaten fruit. Imago flying. Very common in January and from then on till April.

Food Plants.—Pomegranate, loquat, guava, *Randia dumetorum* (de N.).

Status.—Local sporadic pest of cultivated pomegranate.

Larva.—$\frac{3}{4}$ inch; deep blackish-brown, the anterior segments largest; segments bristly and pitted; the last three segments flattened above.

PIERIDÆ.

PIERIS BRASSICÆ. Linn. Syst. Naturæ, ed. X, p. 467.
Bingham. F. Ind. Butterflies, II, p. 170, (Fig. i).
(*Mancipium nepalensis*). Ind. Museum Notes, II, p. 46.

FIG. 37. PIERIS BRASSICÆ.

Expanse 56—66 m. m. Creamy white, a black blotch at apex of forewing reaching to below middle of outer margin. Female with black blotches on forewing.

Distribution.—Europe, Asia, Japan, North Africa, India, Behar and near Himalayas.

Biology.—Eggs on leaf in clusters. Larva in groups, warningly coloured. Pupa on leaf. In plains only in cold and hot weather.

Food Plants.—Cruciferous plants.

Status.—Sporadic minor pest.

PAPILIONIDÆ.

139. Papilio demoleus.—L. Syst. Nat., ed. X, p. 464.
Bingham. F. Ind. Butterflies, II, p. 39.
Erithoniue de N. Indian Museum Notes, I, p. 93 (Fig. l. p. i).
Indian Insect Pests, p. 174 (Fig. l. p. i).

Fig. 38. Papilio demoleus.

Expanse, 58—75 m. m. Black, much marked with lemon-yellow. A red spot, usually bordered inwardly with blue and black, on the anal angle of the hindwing: a blue ocellus-like mark on black at the costal margin of the hindwing.

Distribution.—In India, hills and plains. The orange butterfly of Natal.

Biology.—Egg singly on leaf. Larva on the plant, feeding exposed; mimics bird dropping when young, protectively coloured when old; larva with warning eversible process. Pupa on plant. Found almost throughout the year in the plains. Hibernation as imago.

Food Plants.—Citrus plants. Bael (*Aegle marmelos*), ber (*Zizyphus jujuba*), and *Glycosmis pentaphylla.*

Status.—Minor pest of fruit trees.

Larva.—(Young) Dirty brown, with stumpy projections; a white blotch on the middle segments, dorsally. (Old) Deep green, above; with purple grey below, across the body at the junction of the thorax and abdomen, and stretching up obliquely on abdomen.

HESPERIIDÆ.

10. PARNARA (CHAPRA) MATHIAS.—Fabr. Ent. Syst. Suppl., p. 433.
Indian Museum Notes, V, 137 (Fig. i).
Indian Insect Pests, p. 122.

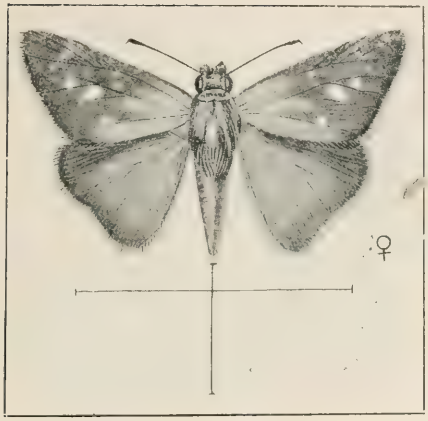


FIG. 39. CHAPRA MATHIAS. FEMALE.

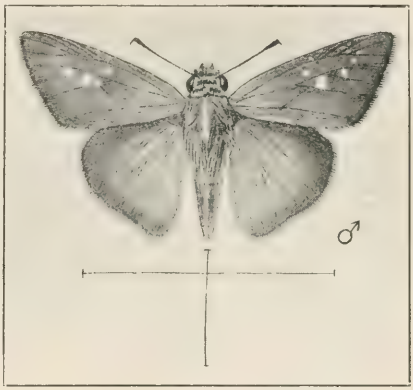


FIG. 39. CHAPRA MATHIAS. MALE.

Expanse, 27—33 m. m. Deep brown with an olive green sheen. Both wings with small white spots.

Distribution.—India, general in the plains. Africa, Java.

Biology.—Larva in rolled up leaf, eating all but the midrib. Pupa in rolled leaf. Found only in rains, two broods. Hibernation uncertain.

Food Plant.—Rice.

Status.—Minor pest.

Larva.—1½ inches. Green, with a white lateral line. The head with red marginal band.

Pupa.—Grass green, with white lateral line.

SPHINGIDÆ.

193. ACHERONTIA STYX.—Westw. Cab. Or. Ent. p. 88. Hmpsn. F. Ind. Moths, I, p. 67, (Fig. l. i). Indian Insect Pests, p. 160 (Fig. l., p. i).

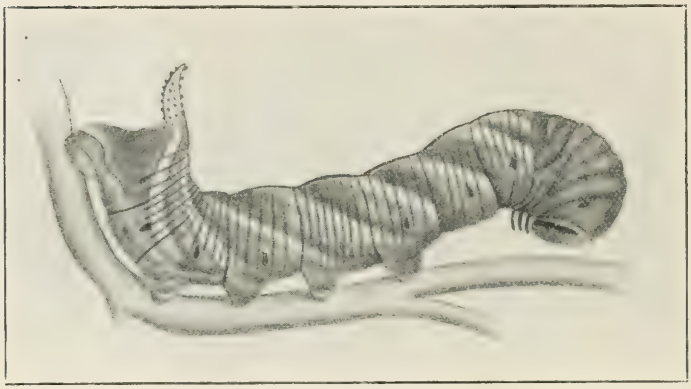


FIG. 40. ACHERONTIA STYX. LARVA.
(From Moore.)

Expanse 8—16 m. m. Thorax dark grey-blue, with a skull mark; abdomen yellow with black bands and a narrow medial blue-grey stripe. Forewing dark brown and grey. No black patch at base of hindwing and much yellow on the abdomen (cf. *lachesis*).

Distribution.—Asia Minor, China, Siam, Borneo, Celebes, Timor, Philippines, Japan, India, Ceylon. Throughout the plains.

Biology.—Egg singly on leaf. Larva typical leaf-eating caterpillar feeding concealed. Pupa in soil. No hibernation in plains, from two to four broods per annum, in (January), May, (August), and October, where food is available. Pupa may rest for three months.

Food Plants.—Til, kulthi, popat, a wild creeper.

Status.—Minor pest of til, rarely abundant.

Larva.—Green with oblique lateral stripes of yellow, edged with blue. Horn recurved and tuberculate.

Pupa. No external proboscis sheath; chestnut brown.

SPHINGIDÆ—(*contd.*)

230. HERSE CONVOLVULI.—Linn. Syst. Nat., I, p. 798. (*Protoparce*). Hmpsn. F. Ind. Moths, I, p. 103 (Fig. i). Indian Insect Pests, p. 159.

Expanse, 80—120 m.m. Grey, marked and clouded with black. Abdomen with lateral bands of pink and black. The grey wings and pink-banded abdomen are distinctive.

Distribution.—Europe, Africa, Asia, Borneo, Java, Celebes ; in India, in plains.

Biology.—Egg singly on leaf. Larva feeding in concealment on leaves. Pupa on surface of soil. Hibernation uncertain, as pupa in the insectary.

Food Plants.—Sweet potato, Sunflower.

Status.—A minor pest, rarely injuriously abundant, occasionally in swarms.

Larva.—$3\frac{1}{2}$ inches long, green, horn yellow. Oblique lateral stripes on abdomen.

Pupa.—With an external proboscis sheath, red brown.

COSSIDÆ.

ZEUZERA COFFEÆ.—Nietn. Edin. New. Phil. Journ. XV, 1862, p. 36.
Hmpsn. F. Ind. Moths, I, p. 312.
Bidie, Rept. on Ravages of the Borer, 1869, Madras (Figs.).
Indian Museum Notes, II, III (Fig. l. p. i).

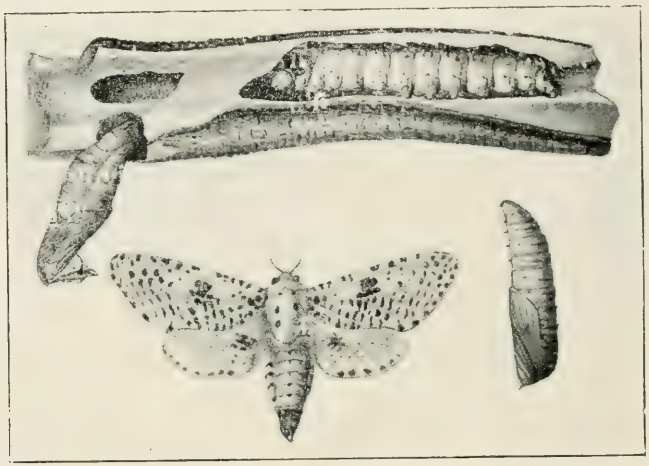


FIG. 41. ZEUZERA COFFEÆ.
Larva in coffee branch, pupa emerging, imago.

Expanse, male 40, female 46 m. m. Head and thorax grey, with black spots. Wings white with blue-black spots at edges. Abdomen, black with white hair.

Distribution.—Naga Hills, Rangoon, Ceylon, Borneo, Cachar (I. M.), Sikkim, Bhutan (Ddgn). Coffee districts of South India.

Biology.—Larva tree boring. Pupa in bore, emerging partially before escape of moth. ? One brood annually.

Food Plants.—Coffee, sandal.

Status.—Serious pest of coffee. 'The Red Borer.'

Larva.—2 inches, red-brown, smooth. Thoracic shield black.

LASIOCAMPIDÆ.

205. Trabala vishnu. Lef. Zool. Journ., III, p. 27.
Hmpsn. F. Ind. Moths, I, p. 421.
Indian Insect Pests, p. 158.

Male 50—60 m. m. Female 80—90 m. m. Male pale green, with an oblique line across wings. Inner area of hindwing white. Female yellow, an oblique line across wings, a red-brown patch on inner margin, a dark spot and an outer series of fuscous markings.

Distribution.—China, Java, India, Ceylon, Burma. In India principally Himalayan and sub-Himalayan.

Biology.—Eggs in double rows. Larva leaf-eating, hiding by day at root of plant. Pupa in cocoon of hairs on soil or on plant. Hibernation as pupa. About three broods in year, dependent upon food supply.

Food Plants.—Castor, Sal, Country almond.

Status.—Sporadic pest of castor, destructive when abundant.

Larva.—$2\frac{1}{2}$ inches. Clothed in grey and black hair ; head yellow with crimson patches ; prothorax bears a large tuft of black hair, projecting forwards.

HYPSIDÆ.

55. ARGINA SYRINGA. Cram. Pap. Exot. I, pl. v, Fig. c.
Hmpsn. F. Ind. II, p. 51. (*Arctiidæ*).
Indian Insect Pests, pp. 194, 148.
Agric. Journ. India. Vol. I, p. 187, (Fig. i.)

Expanse, 60—64 m. m. Head and thorax pinkish brown. Forewing pinkish brown with black spots ringed with yellow. Hindwing crimson with black spots.

Distribution.—Australia, India, Ceylon. In India, hills and plains.

Biology.—Eggs in clusters. Larva a typical leaf-eating hairy caterpillar, feeding exposed. Pupa in cocoon on soil. Hibernation as pupa.

Food Plants.—Sann hemp. and wild *Crotalaria.*

Status.—With *A. cribraria,* but rarer. Minor pest.

Larva.—Similar to *A. cribraria.*

Hypsidæ—(*contd.*)

56. Argina cribraria.—Clerck. Icon. Ins. II, pl. 54, Fig. 4.
Hmpsn. F. Ind. Moths, II, p. 51. (*Arctiidæ*).
Indian Insect Pests, pp. 148 193, (Fig. 1, p. i).
Agric. Journ. India, I, p. 187 (Fig. i).

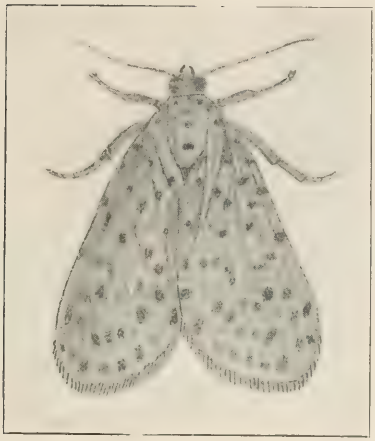


Fig. 42. Argina cribraria.
Resting attitude.

Expanse, 35—50 m.m. Male smaller. Head and thorax orange yellow; forewing orange yellow, with black spots ringed with dull grey. Hindwing orange with black spots.

Distribution.—Mauritius, China, New Guinea, India, Ceylon, Burma. Common in the plains.

Biology.—Eggs in clusters. Larva a leaf-eating hairy caterpillar, feeding exposed. Colouration warning. Pupa in thin cocoon on soil. Hibernation as pupa. Found chiefly in rains, depending upon food supply. Five or more broods before cold weather.

Food Plant.—Sann hemp.

Status.—Sporadic minor pest of Sann. Injurious when abundant.

Larva.—1 inch. Head reddish-brown, shining. Dorsal surface of body white, with lateral black line, black lines and patches entering and crossing the white. A lateral yellow line, with an orange spot in each segment. Hairs black above, light below.

ARCTIIDÆ.

136. DIACRISIA OBLIQUA.—Wlk. Cat. III, 679.
Hmpsn. Lep. Phal. III, p. 289.
Hmspn. F. Ind. Moths, II, p. 7 (Male only).
Indian Insect Pests, p. 193 (Fig. 1. i).
Agric. Journ. India, I., p. 187 (Fig. i).

FIG. 43. DIACRISIA OBLIQUA, larva.

Male 42—58 m.m. Female 50—66 m.m. Pale buff; forewing with black striæ and points; hindwing with black spots. Wings suffused with crimson in *var confusa*. Abdomen crimson with dorsal, lateral and sublateral series of black spots. Spots on wings often obsolete. *Var confusa* is chiefly concerned. Distinct by the red suffusion of wings, which is not however universal in all of a brood. The buff colour and spots separate from *Amsacta* below.

FIG. 44. DIACRISIA OBLIQUA.

Distribution.—Japan, China, India, Burma. The variety *confusa*, Bombay, Travancore, Burma (Hmspn.), Behar, Oudh, Balaghat.

Biology.—Eggs in clusters. Larva the typical hairy caterpillar, occurring in swarms. Feed openly, colouration warning. Pupa in cocoon of silk and hairs on soil. Hibernation from November to February. Six broods yearly.

Food Plants.—Labiate weeds, groundnut, mangel wurzel, sunflower, til, jute, sann hemp, cotton, rice, peas, bajra, urad, soy bean, juar, maize, linseed. In swarms fairly omnivorous.

Status.—Locally a serious sporadic pest, one of the major general pests. Destructive principally in sub-Himalayan districts of Behar and Oudh.

Larva.—1 inch. Hairy. Head black. Thoracic segments orange with black blotches. Abdominal segments orange with rounded tubercles dorsally and laterally. Last two segments black.

Arctiidæ—(*contd.*)

233. Amsacta Moorei. Butl. Cist. Ent. II, p. 23.
(*Creatonotus*). Hmspn. Lep. Phal. III, p. 329.
Hmpsn. F. Ind. Moths,II, p. 27.
(*Creatonotus*). Indian Museum Notes, V, p. 50.
Indian Insect Pests, p. 193.
Agric. Journ. India, I, p. 187 (Fig. i).

Fig. 45. Amsacta Moorei,
×2.

Expanse, male 38—40 ; female 44—54 m. m. White, abdomen scarlet above, with lateral spots and dorsal bands black. Forewing with scarlet costa. Hindwing with black lunule and three black spots. Male antennæ fasciculate.

Distribution.—N.-W. Himalayas, Sind, Bombay, Baroda, Trichinopoly, S. Arcot, Pusa, Ranchi.

Biology.—Larva swarming hairy caterpillar. Pupa in cocoon on soil. Hibernation as pupa ; found in rains.

Food Plant.—Groundnut.

Status.—Minor sporadic pest.

ARCTIIDÆ—(*contd.*)

220. AMSACTA LACTINEA. Cram. Pap. Exot. II, pl. 133.
Hmpsn. Lep. Phal. III, p. 328 (Fig. i).
Hmpsn. F. Ind. Moths, II, p. 27 (Fig. i).
Creatonotus. Indian Museum Notes, III and IV.
(? *A. lineola*). Indian Insect Pests, p. 193 (Fig. i).
Agric. Journ. India., I, p. 187 (Fig. i).

FIG. 46. AMSACTA LACTINEA.

White. Crimson costal fascia to forewing, extending to thorax and coxæ. Abdomen orange above, black bands and lateral spots. A variable number of black spots on the hindwing.

Distribution.—China, Japan, Java, Formosa, India, Burma, Ceylon. In India, plains and hills.

Biology.—Eggs in clusters. Larva a typical hairy caterpillar. Pupa in cocoon of silk and hair on soil. Hibernation as pupa. Found in rains, three to four broods from June to November.

Food Plants.—Sweet potato, sunflower, rice, til, juar, weeds.

Status.—Doubtful. Records in Indian Museum Notes cannot be accepted. Probably *A. lineola* is the species there referred to.

Larva.—1½ inches. Black with dense tufts of brown hair.

ARCTIIDÆ—(*contd.*)

232. AMSACTA LINEOLA. Fabr. Ent. Syst. III (1), p. 465.
Hmpsn. Lep. Phal. III, p. 324.
(*Creatonotus emittens*), Hmpsn. F. Ind. Moths, II, p. 29.
(*Creatonotus emittens*), Indian Museum Notes, V, p. 57.
Agric. Journ. India, I, p. 187 (Fig. i).

Male 30. Female 38 m. m. White, tinged with pink. A crimson fascia on costa and a black fascia in middle of forewing. Hindwing white. Abdomen crimson, with dorsal series of black spots. Antennæ of male bipectinate.

Distribution.—Throughout India; Ceylon. In India, hills and plains.

Biology.—Typical swarming hairy caterpillar. Pupa on soil in cocoon of silk and hairs. Hibernation as pupa. About three broods in rains.

Food Plant.—Indigo.

Status.—Doubtful. Minor sporadic pest.

ARCTIIDÆ—(*contd.*)

137. UTETHEISA PULCHELLA. Linn. Syst. Nat. I, II, p. 884. Hmpsn. Lep. Phal. III, p. 483 (Fig. i).
(*Deiopia*). Hmpsn. F. Ind. Moths, II, p. 55 (Fig. i). Indian Insect Pests, p. 148 (Fig. 1, i). Agric. Journ. India, I p. 187 (Fig. i)

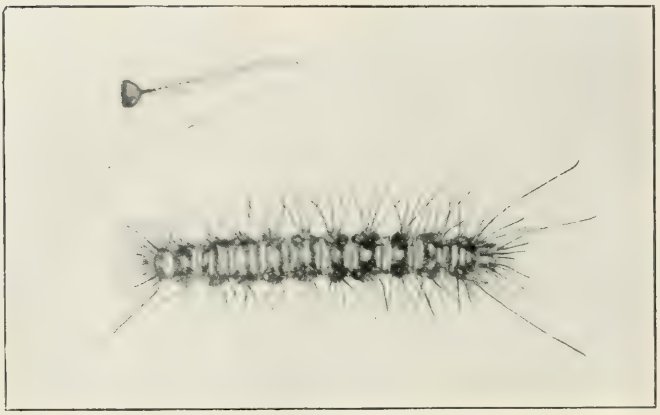


FIG. 47. UTETHEISA PULCHELLA, larva, ×2, and one hair.

Expanse, 40—46 m. m. Forewing white or yellowish white, spotted in red and black. Hindwing white with black patch. Colouring distinctive.

Distribution.—Europe, Africa, Philippines, Malay Archipelago, New Guinea, Australia, India, Burma, and Ceylon. In India, hills and plains.

FIG. 48. UTETHEISA PULCHELLA, ×2¼.

Biology.—Eggs in clusters on plant. Typical swarming caterpillar feeding exposed, with warning colouration. Pupa in light cocoon on soil. Hibernation as pupa. Moth day-flying. About six broods yearly if food available.

Food Plant.—Sann hemp.

Status.—Minor sporadic pest, occasionally in swarms.

Larva.—1 inch. Dark above, greenish below. Median dorsal line is yellow white, with brown transverse marks; lateral stripes yellowish with oblique dark marks. Hairs, black above, white below.

NOCTUIDÆ.

9C. CHLORIDEA OBSOLETA.—Fabr. Ent. Syst. 3, 1, p. 456.
(*Armigera*). Hmpsn. Lep. Phal. IV, p. 45 (Fig. i).
(*Heliothis armigera*). Hmspn. F. Ind. Moths, II, p. 174 (Fig. i).
" " Haymann, Report of Cawnpore Farm, 1903, p. 19.
" " Indian Museum Notes, I-V, (Fig. l. p. i.).
Indian Insect Pests, p. 144 (Fig. l. p. i.).

FIG. 49. CHLORIDEA OBSOLETA, pupa and imago, ×2.

Expanse, 31—41 m. m. Olive grey to red brown. Forewing with a dark speck and a dark area near the outer margin. Hindwing with a dark outer border. The postmedial line in distinct and strongly dentate. *Distribution.*—Universal. In India, throughout the plains and hills. The bollworm of America.

Biology.—Eggs singly. Larva typically a pod borer, not entering the pod, feeding from outside. Pupa in soil. Hibernation uncertain, does not normally occur except in exceptional cold. In plains active throughout the year. About eight broods in the year.

Food Plants.—Opium, lucerne, gram, mangel wurzel, ganja, peas, indigo, tobacco, tur and other pulse, oats, maize, castor seeds, *Datura stramonium*, onion, tomato, bajra heads, sunflower seeds, carrot. Flower buds of cotton, very rarely.

Status.—A widespread and general pest, rarely serious but causing a large aggregate damage. Occasionally very serious in late rabi crops. Found with swarming caterpillars.

Larva.—1½ inches. Head brown. Thorax and abdomen smooth, general colour greenish, with fine longitudinal lines of black and yellow, making a mid-dorsal and lateral bands. Distinct black papillæ from which rise short white hairs.

NOCTUIDÆ—(*contd.*)

158. CHLORIDEA ASSULTA.—Guen. Noct. II, p. 178.
Hmspn. Lep. Phal. IV, p. 47 (Fig. i).
Ind. Ins. Pests, p. 157.

24—36 m. m. Orange, the postmedial line of forewing distinct.

Distribution.—Asia, Africa, Australia. In India, plains and hills.

Biology.—Like *C. obsoleta.* F.

Food Plants.—Tobacco, tiparee.

Status.—Occasional pest of tobacco.

Larva.—Indistinguishable from C. *obsoleta.* F.

NOCTUIDÆ—(*contd.*)

238. EUXOA SEGETIS.—Schiff. Wien. Verz. pp. 81, 252.
Hmspn. Lep. Phal. IV, p. 167 (Fig. i).
Agrotis, Hmspn. F. Ind. Moths, II, p. 181 (Fig. i).
„ Indian Museum Notes, III, IV, V (Fig. l., p. i).
Indian Insect Pests, p. 288 (Fig. i).
Agric. Journ. India, Vol. II, p. 42 (Fig. i).
Mem. Agric. Dept., Vol. I, No. 3 (Fig. i).

Expanse, 42—48 m. m. Whitish brown or fuscous. Collar with dark line. Markings characteristic but often obscured. Closely similar in general appearance to *Caradrina exigua* but larger, the wing markings dark, not ochreous.

Distribution.—Europe, Africa, Asia. In India, principally a Himalayan and hill form extending into the Ganges valley, and some localities near hills.

Biology.—Larva a surface caterpillar or a swarming caterpillar. Pupa in the ground. Hibernation from December to February.

Food Plants.—Coffee, indigo, weeds.

Status.—Doubtful; in the hills a doubtful general pest.

Larva.—Pale grey, or greyish ochraceous, sometimes pink tinged dorsal, subdorsal and spiracular line usually indicated by dark edges, subdorsal sometimes grey. Head pale with two brown marks. (Meyrick).

NOCTUIDÆ—(*contd.*)

239. EUXOA SPINIFERA.—Hubn. Samml. Eur. Schmett. f. 389.
Hampsn. Lep. Phal. IV, p. 177.
Agrotis biconica, Hampsn. F. Ind., Moths, II, p. 108.
Indian Museum Notes, IV, p. 195.
Indian Insect Pests, p. 188.
Agric. Journ., India, Vol. II, p. 42 (Fig. i).
Mem. Agric Dept., Ent. Vol. I, No. 3 (Fig. i).

26—40 m. m. Two dark fasciæ on the forewing. Hindwing white.

Distribution.—Europe, Africa, Syria, Persia, Kashmir. India, principally the hills and more rarely in the plains.

Biology.—Larva a surface caterpillar. Pupa in soil. Hibernation in colder parts of the plains, December to February.

Food Plants.—Cotton, indigo, tobacco, grasses.

Status.—Occasional minor pest.

Larva.—Closely resembling *A. ypsilon* but browner.

NOCTUIDÆ—(*contd.*)

240. AGROTIS YPSILON.—Roth. Naturf. IX, p. 141.
Hmpsn. F. Ind. Moths, II, p. 182.
Hmpson. Lep. Phal. IV, p. 368 (Fig. i).
(*Suffusa*). Indian Museum Notes, I—V (Figs. 1., p. i).
Indian Insect Pests, p. 188.
Agric. Journ India, Vol. II., p. 42 (Fig. e. l, p. i.).
Mem. Agric. Dept. Ent. Vol. I., No. 3 (Fig. e. l., p. i).

Expanse, 42—56 m. m. Forewing dark, sub-marginal line dentate with two black streaks. Moth darker than the other species, the dentate sub-marginal line distinct.

Distribution.—Almost universal. The "Greasy cutworm" of America. In India, chiefly if not entirely Himalayan and Ganges valley.

Biology.—Eggs singly or in clusters. Larva living in the soil in a burrow from which it emerges to feed. When abundant, forms part of the swarming caterpillars that devastate large areas and then moves from field to field. Pupa in the soil. Hibernation in unusual cold; pupæ do not generally transform in cold weather, but larvæ remain active; pupal hibernation December to February. Number of broods unknown and probably variable according to food supply.

Food Plants.—Tobacco, opium, cabbage, lucerne, mangel wurzel, gram, groundnut, potato, cruciferous vegetables, mustard, linseed, wheat, barley, oats, peas and hops.

Status.—A major pest, destructive to young field crops; chiefly known in rabi crops in Ganges valley, where it also occurs in swarms in late rabi. A "surface caterpillar" and a "swarming caterpillar." Occurrence local, dependent upon parasites, weather and food supply.

Larva.—1½ inches. Smooth with a greasy appearance. Dull grey, lighter below, with small shiny black spots.

NOCTUIDÆ—(*contd.*)

237. AGROTIS FLAMMATRA.—Schiff. Wien. Verz., p. 80.
Hmpsn. Lep. Phal. IV, p. 393.
Hmpsn. F. Ind. Moths, II, p. 189.
(*Ochropleura*). Indian Museum Notes, II, III (Fig. i).
Indian Insect Pests, p. 188 (Fig. i).
Agric. Journ. India, Vol. II, p. 42 (Fig. i).
Mem. Agric. Dept. Vol. I, No. 3 (Fig. i).

Expanse, 56 m. m. Collar with a black triangular mark. Markings characteristic. Hindwing dark.

Distribution.—Europe, Syria, Persia, Siberia, India, Kashmir, Himalayas, Punjab, sub-Himalayan areas.

Biology.—Larva at roots of plants or as a surface caterpillar, rarely swarming. Pupa in the soil. Hibernation December to February.

Food Plants.—Opium, weeds, tobacco.

Status.—A possible pest, scarcely ever reported.

Noctuidæ—(*contd.*)

53. Prodenia Littoralis. Boisd. Faun. Ent. Madag. Lep., p. 91.
Hmpsn. F. Ind. Moths, II, p. 247 (Fig. i).
Indian Museum Notes, II, III, IV (Fig. l., p. i).
Indian Insect Pests, p. 156 (Fig. l., p. i).

Expanse, 30—45 m. m. Forewing marked with ochreous and brown, with a pale blue fascia near apex, often absent. Hindwing white. Markings variable but characteristic.

Distribution.—Tropical and sub-tropical zones. In India, hills and plains, practically universal.

Biology.—Eggs in clusters clothed with hair. Larva leaf-eating, similar to surface caterpillars and forming part of swarming caterpillars. Hibernation in colder parts of the plains as larva or pupa. Imago out in March. Hibernation rarely as imago. Number of broods about eight where food is available, about five in rains with a hibernation brood.

Food Plants.—Tobacco, marua, indigo, castor, Pakur tree (*Ficus infectoria*), lucerne, urid, cabbage, wheat, cauliflower, groundnut, rice, celery, grassroots, tur, sweet potato, sugarcane, coleus, maize; mulberry, potato (Ind. Mus. Notes). When in swarms, fairly omnivorous.

Status.—An important tobacco pest at all stages. A serious swarming caterpillar in late rabi, in indigo or in early monsoon crops. A general major pest.

Larva.—1½ inches. Velvetty black. Head small. Thorax and abdomen with yellow green dorsal lines and a lateral white band. Yellow spot on each segment laterally, variable. Young larva has the junction of thorax and abdomen slightly swollen and dark coloured.

NOCTUIDÆ—(*contd.*)

235. SPODOPTERA MAURITIA.—Boisd. Faun. Ent. Madag. Lep., p. 92.
Hmpsn. F. Ind. Moths, II, p. 248.
Indian Museum Notes, V, p. 48.
E. E. Green, Trop. Agric., 1905, p. 6 (Fig. l., p. i).
Indian Insect Pests, pp. 122, 189.

Expanse, 38 m. m. Fore-tibia with tufts of hair. Forewing grey-brown with a black spot, and an irregularly waved light line. Hindwing white. The tufts of hair on the fore-tibia are a good character. Markings not very distinct.

Distribution—West Africa, Mauritius, Shanghai, Oriental and Australian regions. In India, principally a hill form, abundant locally near hills.

Biology.—Larva a swarming caterpillar, similar to the American "Army worm". Pupa in the soil. Hibernation as pupa.

Food Plants.—Rice, maize, marua, grasses.

Status.—A serious swarming caterpillar, appearing sporadically on rice and neighbouring crops. Distinctly a major pest of occasional occurrence.

Larva.—$1\frac{1}{2}$ inches. Grey. Thorax and abdomen smooth, thorax with longitudinal lines. Abdomen with a median reddish band, two longitudinal dorsal lines and a lateral yellow stripe. Crescent shaped black spots on each segment.

NOCTUIDÆ—(*contd.*)

110. CARADRINA EXIGUA.—Hubn. Samml. Eur. Schmett. Noct., Fig. 362.
Hmpsn. F. Ind. Moths, II, p. 259.
(*Laphygma*). Ind. Museum Notes, III, 6, p. 15 (Fig. i).
(*Agrotis segetis*). Ind. M. Notes, V. 3, p. 145 (Fig. l., p. i).
Indian Insect Pests, p. 187 (Fig. l).
Agric. Journ. India, I, p. 338 (Fig. e. l., p. i).

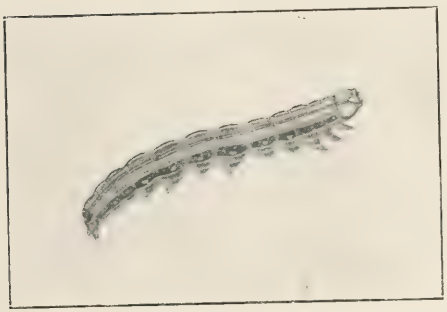


FIG. 50. CARADRINA EXIGUA, larva, ×2.

Expanse, 26—32 m. m. Resembles *Euxoa segetis*, but is smaller. An ochreous spot on the forewing. A series of black sub-marginal specks. Hindwing white, veins and margin fuscous.

Distribution.—Europe, South Africa, North and South America, Oriental region, Honolulu. In India, hills and plains.

Biology.—Eggs in clusters. Larva a swarming caterpillar feeding by day and hiding on the soil in the heat. Pupa in the soil. Life-history very rapid, less than twenty days. Hibernation as pupa.

Food Plants. Lentil (I.M.N.); indigo, cabbage, lucerne, ambadi, jute, maize, bhinda, mangel wurzel, safflower, cotton, amaranths, peas.

Status.—A voracious swarming caterpillar, occurring principally in irrigated crops in March, April. Noticed chiefly when concentrated on small areas.

Larva.—1 inch. Green, a median dorsal and a lateral dark line, on the latter eight white spots and below a lateral yellow line; colour very variable.

NOCTUIDÆ—(*contd*)

114. CIRPHIS LOREYI.—Dup. Lep. Fr. VII, p. 81.
Hmpsn. Lep. Phal. V, p. 492 (Fig. i).
(*Leucania*). Hmpsn. F. Ind. Moths, II, p. 274.
Indian Museum Notes, I, 51.

Expanse, 34—42 m. m. Ochreous. Forewing with a dark suffusion on median nervure; postmedial curved series of specks, white speck at lower angle of cell. The clearer wing, with white spot and postmedial specks distinguish this from *L. unipuncta*.

Distribution.—Europe, India, Burma, Cyelon. In India, hills and plains.

Biology.—Larva leaf-eating or behaving as a surface caterpillar. Pupa in cell in earth. Hibernation unknown.

Food Plants.—Maize, gram.

Status.—A minor pest, status doubtful.

Larva.—1 inch. Brown: a light lateral line, a dark dorsal line. Spots of black and white on the segments.

Noctuidæ—(*contd.*)

29. Cirphis unipuncta.—Haw. Lep. Brit., p. 174.
Hmpsn. Lep. Phal. V, p. 547.
Leucania Hmpsn. F. Ind. II, p. 275.
Leucania extranea Ind. M. Notes, II, III, IV (Fig. l., p. i).
Indian Insect Pests, p. 138 (Fig. l., p. i.).

Expanse, 44—50 m. m. Like *loreyi*, but the forewing with dark specks and blotches, the ground colour often redder; white speck in cell minute; black specks on apical half of wing. Superficially recognizable from *C. loreyi* by the more dusky wing, less distinct white spot and black dots.

Distribution.—Universally distributed. In India, hills and plains. The "Army worm" of the United States and Canada. A pest in Queensland (Tryon).

Biology.—Eggs singly or in clusters. Typically a leaf-eating caterpillar that becomes a swarming caterpillar when abundant. Pupa in soil. Hibernation to March. Appears in hot weather when food is available.

Food Plants.—Juari, maize, rice.

Status.—Injurious to young juari, or to juari and maize at any stage if sufficiently abundant. Very injurious to rice.

Larva.—1 inch. Grey-brown. Prothorax with dark shield and three light lines. A dark lateral stripe on remaining segments. A plate over the base of each sucker foot.

NOCTUIDÆ—(*contd.*)

91. NONAGRIA UNIFORMIS.—Ddgn. Journ. Bo. Nat. Hist. Soc. XV, p. 402.
Indian Museum Notes, V, p. 178 (Fig. l., p. i.).
Indian Insect Pests, p. 123 (Fig. l., p. i.).

FIG. 51.
NONAGRIA UNIFORMIS × 2.
INPERENS.

Expanse, 28 m. m. Ochreous, forewing with a red brown suffusion along median nervure. Marginal dark line. Hindwing white. Antennæ of male fasciculate (cf. N. inferens).

Distribution.—Surat, Nagpur, Behar, Cuttack, Jullundur, Coimbatore. Probably general in the plains.

Biology.—Eggs in clusters. Larva boring in stems. Pupa in the stem. Active in cold weather in plains.

Food Plants.—Cane, juari, wheat, maize, rice, sama, Guinea grass.

Status.—Serious local pest of wheat, somewhat sporadic so far as known. Occasional and general pest of other crops.

Larva.—1 inch. Flesh colour. Head black; prothorax large, with slight dorsal thickening. Anal segment with darker dorsal patch. Rest of body smooth, unstriped.

NOCTUIDÆ—(*contd.*)

152 TARACHE CATENA.—Sow. Brit. Misc., p. 29, pl. xiv.
Hmpsn. F. Ind. Moths, II, p. 312.
Indian Insect Pests, p. 112.

Expanse, 40 m. m. Pure white. Forewing marked with leaden patches. Hindwing pearly with a marginal fuscous band. The white wings with leaden markings are very distinct.

Distribution.—Abyssinia, Natal. In India, Sind, Bombay, Baroda, Coimbatore, Surat, Nagpur, Jhelum and Chenab colonies, Punjab.

Biology.—Larva a typical leaf-eating semi-looper. Found in the rains. Pupa in soil.

Food Plants.—Cotton; maize.

Status.—A minor pest, rarely occurring in large numbers.

Larva.—1 inch. Green or brown. Semi-looper, abdominal 1—2 and anal segments smaller. Thorax with many black speckles, abdomen with orange and black marks on round protuberances on anterior segments. Prolegs on abdomen 5, 6 and anal segment.

NOCTUIDÆ—(*contd.*)

117. ACONTIA MALVÆ.—Esper. Schmett. IV. 2, p. 63.
Hmpsn. F. Ind. Moths, II, p. 322.
Indian Insect Pests, p. 167.

Expanse, 30—36 m. m. Head whitish, thorax canary yellow. Forewing canary yellow with rufous markings. Hindwing white, rarely suffused in part with brown. (Cf. *A. transversa* and *A. intersepta* with specimens.)

Distribution.—Europe, Formosa, India.

Biology.—Larva the typical leaf-eating semi-looper. Pupa in earth in cell of earth and silk. Found in rains and hot weather.

Food Plants.—Bhinda, cotton.

Status.—Minor pest.

Larva.—1 inch. Green, semi-looper. Head large, green with short hairs. Thorax and abdomen green, with minute black markings; round tubercles on each segment with a dark apex and a long hair.

NOCTUIDÆ—(*contd.*)

58. ACONTIA TRANSVERSA.—Guen. Noct. II, p. 211.
Hmpsn. F. Ind. Moths, II, p. 323.
Indian Insect Pests, p. 167.

Expanse, 40—44 m. m. Like *A. malvæ*. Palpi, legs red-brown. Vertex of thorax rufous, male with palpi more hairy in front, tibiæ clothed in long hair.

Distribution.—China, Java, India, Burma, Ceylon.

Biology.—Larva the usual semi-looping leaf-eating caterpillar. Pupa in soil or fold of leaf. Found in rains.

Food Plant.—Bhinda.

Status.—A minor occasional pest.

Larva.—Similar to *A. malvæ*.

NOCTUIDÆ—(*contd.*)

154. EUBLEMMA OLIVACEA. Wlk. Cat. XII, p. 795.
Hmpsn. F. Ind. Moths, II, p. 342.
Indian Insect Pests, p. 166.

Expanse, 22—26 m. m. Forewing white with olive green patches, black specks and some rufous suffusion.

Distribution.—Punjab, Coimbatore, Ceylon, Dharwar, Pusa.

Biology.—Larva bores in green stems and twigs. Pupa in stem, found in rains.

Food Plant.—Brinjal (*Solanum melongena*).

Status.—Minor occasional pest.

NOCTUIDÆ—(*contd.*)

115. COSMOPHILA EROSA.—Hübn. Zutr. Samml. exot. Schmett. II, 19.
Hmpsn. F. Ind. Moths., II, p. 411.
Haymann, Report of Cawnpore Farm, 1904, p. 21.
Indian Insect Pests, p. 112.

Expanse, 38 m. m. Male: forewing, base orange irrorated with red, apex grey with a purple and orange suffusion; hindwing fuscous. Female: forewing orange with the apical half slightly suffused with purple, basal half with waved brown lines; hindwing orange marginally suffused with fuscous. Markings characteristic, readily recognized.

Distribution.—United States, West Indies, South Africa, Madagascar, Mauritius, Oriental region, Australia; general in the plains.

Biology.—Larva leaf-eating. Pupa in soil or fold of leaf. Found in rains.

Food Plants.—Cotton, ambadi, hibiscus, *Malachra capitata.*

Status.—Sporadic minor pest of cotton.

Larva.—1 inch. Semi-looper. Green with a lateral white streak. Median band of alternating white and dark streaks. Minute white dots laterally at equal distances.

NOCTUIDÆ—(*contd.*)

229. COSMOPHILA SABULIFERA.—Guen. Noct. II, p. 404.
Hmpsn. F. Ind. Moths, II, p. 409.
Indian Insect Pests, p. 151.
Agric. Journ. India, II, p. 109 (Fig. e. l., p. i).

Expanse, 32—38 m. m. Dull earth-brown, with darker spots, suffusion or waved lines on forewing. Colour distinguishes it from *C. erosa.* Markings variable.

Distribution.—Africa, Aden, Ceylon, Burma. India, throughout the plains.

Biology.—Egg singly on leaf, larva a typical leaf-eating semi-looper. Pupa in thin cocoon in soil. Found in rains, more rarely in hot weather.

Food Plant.—Jute.

Status.—A somewhat serious sporadic pest of jute.

Larva.—$1\frac{1}{2}$ inches. Semi-looper, one rudimentary, two abdominal and anal sucker feet. Green, with five dark tubercles on each segment bearing short hairs.

Noctuidæ—(*contd.*)

73. Earias fabia.—Stoll. Cram. Pap. Exot. IV, pl. 355.
Hmpsn. F. Ind. Moths, II, p. 133.
Indian Museum Notes, V (Fig 1, p. i).
Haymann, Report of Cawnpore Farm, 1902.
Indian Insect Pests, p. 89 (Fig. 1, p. i).
Agric. Journ. Ind., I, p. 54 (Fig. 1, p. i).

Fig. 52. Earias fabia, larva ×4.

Fig. 53. Earias fabia, ×2.

Expanse, 20—26 m. m. Head and thorax ochreous white, forewing ochreous, with a longitudinal green wedge-shaped band, often absent. Moth recognizable by the ochreous or green striped wings.

Distribution.—Ceylon, Java, throughout the plains of India.

Biology.—Eggs singly. Larva a borer in green stems, pods or bolls. Pupa in cocoon on plant or in soil. Hibernation in colder parts of plains. About eight broods in year when food available, more in warmer localities.

Food Plants.—Cotton, bhinda, ambadi, khanghi and wild malvaceæ.

Status.—Major pest of cotton, universal and constant. Great aggregate damage yearly.

Larva.—$\frac{3}{4}$ inch. Short and thick set. Ground colour whitey-green, an irregular broad lateral blotch of greeny white. Yellow spots laterally on each segment and on thoracic 2·3, abdominal 1 dorsally. One short process on each segment, doubled on thoracic 2·3, abdominal 1, bearing a hair.

NOCTUIDÆ—(*contd.*)

108. EARIAS INSULANA.—Boisd. Faun. Madag., p. 121, pl. 16.
Hmpsn. F. Ind. Moths, II, p. 133, (Fig. i).
Haymann, Report of Cawnpore Farm, 1904, p. 16.
Willcocks Yearbook Khedivial Agric. Soc. 1905.
Indian Insect Pests, p. 89.
Agric. Journ., India, I, p. 54.

Expanse, 20—26 m. m. Head, thorax and forewing green, pale specimens with three angled lines on forewing.

Distribution.—Africa, Mauritius, Baluchistan, Burma, Siam. Throughout the plains of India.

Biology.—Eggs singly. Larva a borer in pods, bolls, and green stems. Pupa in tough cocoon on plant or in soil. Hibernation in colder parts of India. About eight broods a year when food available ; more in absence of hibernation.

Food Plants.—Cotton, bhindi, ambadi, khanghi and other malvaceous weeds.

Status.—With *E. fabia*, a major pest of cotton responsible for a large yearly aggregate of loss.

Larva.—Similar to *E. fabia.*

NOCTUIDÆ—(*contd.*)

52. OPHIUSA MELICERTE.—Drury. Ill. Exot. Ins. I, p. 46.
Hmpsn. F. Ind. Moths, II, p. 494.
Indian Museum Notes, I, II, III, V (Fig. l, p. i).
Indian Insect Pests, p. 158 (Fig. l. i.).

FIG. 54. OPHIUSA MELICERTE.

Expanse, 60—70 m. m. Pale reddish brown, wing markings darker, rarely obsolete. Hindwing black with medial band, three marginal spots and cilia white.

Distribution.—Ethiopian, oriental and Australasian regions. In India plains and hills universal.

Biology.—Larva a typical (semi-looper) leaf-eating caterpillar. Pupa in soil. Hibernation occurs the insect being abundant chiefly in the rains.

Food Plants.—Castor; dudhia (*Euphorbia pilulifera*) and probably other Euphorbiaceous weeds.

Status.—A specific pest of castor and as such sporadic and virulent.

Larva. $1\frac{1}{2}$ inches. Semi-looper; colour variable; dark ground with red and white longitudinal stripes. Few hairs. Paired short process on anal segment.

NOCTUIDÆ—(*contd.*)

242. REMIGIA ARCHESIA.—Cram. Pap. Exot. III, pl. 273.
Hmpsn. F. Ind. Moths, II, p. 526.
de Niceville, Indian Museum Notes, V, 126 (Fig. i).

FIG. 55. REMIGIA ARCHESIA.

Expanse, 42—54 m. m. Red-brown. Forewing with darker lines and a lighter submarginal waved line. Hindwing ochreous fuscous with narrow medial and diffused submarginal bands fuscous. Distinct from *frugalis* in colour. Form and marking distinct from all other destructive genera. Moths variable.

Distribution.—Ethiopian and Oriental regions, North China. In India, hills and plains.

Biology.—Larva a leaf-eating semi-looper; pupa in cocoon of leaves and silk on the ground. Hibernation uncertain. Found in the rains.

Food Plants.—Indigo, *Desmodium,* urid.

Status.—A component of the caterpillar swarms on indigo. Sporadic minor pest.

Noctuidæ—(*contd.*)

241. Remigia frugalis.—Fabr. Syst. Ent., VI, p. 601.
Hmpsn. F. Ind. Moths, II, p. 527.
Indian Museum Notes, V, p. 137 (Fig. i).

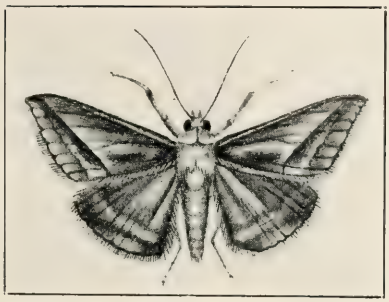


Fig. 56. Remigia frugalis.

Expanse, 36—50 m. m. Grey-brown, like *archesia*, but markings variable and often obsolete. Colour distinguishes it from *archesia*.

Distribution.—West Africa, Oriental and Australian regions. In India, principally in and near hills.

Biology.—Larva a leaf-eating semi-looper. Hibernation uncertain. Found in the rains.

Food Plants.—Rice, maize, juari.

Status.—Minor sporadic pest, rarely forming swarms.

Larva.—1½ inches. Grey-brown. Semi-looper, lighter longitudinal stripes. Few short hairs.

NOCTUIDÆ—(*contd.*)

243. GRAMMODES GEOMETRICA.—Fabr. Syst. Ent., p. 599.
Hmpsn. F. Ind. Moths, II, p. 531 (Fig. i).
Indian Museum Notes, V, p. 139 (Fig. i).

Expanse, 35—45 m. m. Grey-brown with striking black and white markings. Hindwing fuscous with medial pale band.

Distribution.—Europe, Africa, Formosa, Java, Australia, India, Burma, Ceylon. In India, hills and near hills.

Biology.—Larva a semi-looping leaf-eater. Hibernation uncertain. Found in rains.

Food Plant.—Rice.

Status.—Minor pest, sporadic. Component of swarming caterpillar masses.

Noctuidæ—(*contd.*)

244. Ophideres fullonica.—Linn. Syst. Nat., I, 2, p. 812.
Hmpsn. F. Ind. Moths, II, p. 560 (Fig. i).
Indian Museum Notes, V, p. 116.
Indian Insect Pests, p. 177.

Head and thorax red-brown suffused with plum colour. Forewing red-brown with faint markings. Hindwing orange with large black markings. Clearly recognizable by the cilia and markings.

Distribution.—Africa, Oriental region to Australia. In India, hills and near hills.

Biology.—Larva feeds on wild plants. Imago found in rains and before cold weather.

Food Plants.—Imago feeds on fruits.

Status.—A minor pest of orange, the imago being destructive to the fruits.

NOCTUIDÆ—(*contd.*)

100. PLUSIA SIGNATA.—Fabr. Ent. Syst., III, 2, p. 31.
Hmpsn. F. Ind. Moths, II, p. 568.
Indian Insect Pests, p. 155 (Fig. l, p. i).

Expanse, 32 m. m. Can be distinguished only by comparison of accurately named specimens.

Distribution.—West Africa, Ceylon, Java, Fiji. In India, Lahore, Surat and Nagpur.

Biology.—Larva a leaf-eating semi-looper. Pupa in cocoon on leaf. No hibernation in plains; found in cold weather.

Food Plants.—Cabbage and other cruciferous vegetables.

Status.—Minor pest of market garden crops.

Larva.—1 inch. Light green. Semi-looper. Head light green, body green, with longitudinal light stripes and short white hairs.

NOCTUIDÆ—(*contd.*)

284. PLUSIA ERIOSOMA.—Doubl. Dieff. New. Zeal., II, p. 285. Hmpsn. F. Ind. Moths, II, p. 569.

Expanse, 42 m. m.

Distribution.—Indian, Malayan, Australian regions, North and South America, China, Japan, Aden, In India, hills and plains.

Biology.—Egg on leaf. Larva leaf-eating. Pupa in a cocoon of silk and leaves. Active throughout the year in the plains, number of broods unknown.

Food Plants.—Sann, urid, marua, moth.

Status.—Minor pest.

Larva.—Over one inch long, green with white stripes and scattered black spots. Semi-looping, three pairs of prolegs.

NOCTUIDÆ—(*contd.*)

190. PLUSIA NIGRISIGNA.—Wlk. Cat. XII, p. 928.
Hmpsn. F. Ind. Moths, II, p. 570.

Expanse, 40 m. m. Can be distinguished only by comparison with accurately named species.

Distribution.—Himalayas, United Provinces, Behar.

Biology.—Larva a pod borer, similar in habits to *Chloridea obsoleta.* Pupa in soil. Found in cold weather. No hibernation in plains.

Food Plants.—Gram, pea, lucerne.

Status.—Minor pest of gram, sporadic.

Larva.—1 inch. Semi-looper, green, two lateral and a dorsal white line. Short hairs.

NOCTUIDÆ.—(*contd.*)

155. PLUSIA ORICHALCEA.—Fabr. Sp. Ins. II, p. 227.
Hmpsn. F. Ind. Moths, II, p. 573.

Expanse, 44 m. m. Red-brown, the outer area of the forewing golden. Hindwing pale, outer area fuscous.

Distribution.—Azores, Madeira, Canaries, St. Helena, South Africa, Mauritius, Arabia, Japan, China, Formosa, India and Ceylon.

Biology.—Larva a leaf-eating semi-looper. Pupa between folds of leaf, a cold weather species, not hibernating.

Food Plants.—Cruciferous vegetables, weeds, and linseed.

Status.—Minor pest of market gardens.

Larva.—1 inch. Green semi-looper. A transparent median line and a white lateral streak.

NOCTUIDÆ—(*concld.*)

PLUSIA AGRAMMA.—Guen. Noct. II, p. 327.
Hmpsn. F. Ind. Moths, II, p. 574.

Expanse, 40 m. m. Grey-brown, the forewing with patches of bronzy reflections and a postmedial sinuous line.

Distribution.—Japan, Ceylon, Java, Australia, Sikkim, Bombay, Canara, Behar.

Food Plants.—Cultivated cucurbitaceæ.

Status.—Minor pest.

Larva.—$1\frac{1}{2}$ inch. Green, with two lateral white stripes; longish hairs borne on conspicuous black tubercles. Suckerfeet on abdomen 5—6 and tail only.

PYRALIDÆ.

1. CHILO SIMPLEX. Butl. P. Z. S. 1880, p. 690.
   Hmpsn. F. Ind. Moths, IV, p. 26.
   Indian Museum Notes (*Diatræa saccharalis* and *Chilo simplex*). I—V, (fig. 1, p. i).
   Haymann, Report of the Cawnpore Farm, 1902.
   Indian Insect Pests, p. 125 (figs. e, l, p. i).
   Agric. Journ., Ind., I, p. 97 (figs. e, l, p. i).

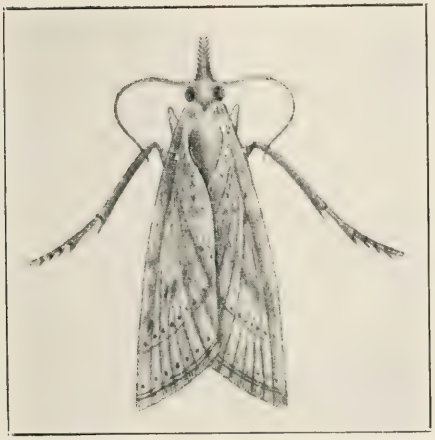


FIG. 57. CHILO SIMPLEX.

Expanse, 22—25 m. m. yellowish-brown, with fuscous suffusion in male and a sub-marginal series of black specks. Hind-wing whitish. The moth is variable in colouration, specially in the relative amount of fuscous on the wings. Male smaller than female, usually darker. The form *partellus* is not distinguishable in the many specimens in the collection.

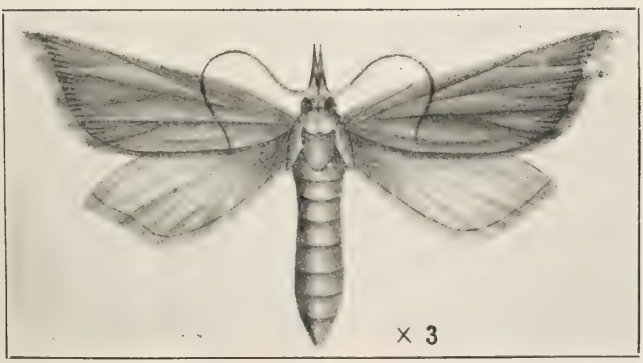


FIG. 58. CHILO SIMPLEX.

Distribution.—Japan, Chusan, Formosa. In India, general in Bengal, Central Provinces, Bombay, United Provinces, Madras, Punjab. Probably throughout India, Burma and Ceylon.

PYRALIDÆ—(*contd.*)

Life History.—Eggs in clusters on leaves. Typically the larva is a borer, living concealed; distinguishable from other cane borers by its habit of boring into the side of old canes, and by its colouration. Hibernates as a larva or pupa in food plant. Breeds in dry hot weather, dependent upon local food-supply. Generally active from March or earlier to November, with about five broods and a hibernation brood.

Food Plants.—Cane (shoots and canes), maize, (cob) tassel, (stem), juari (stem and shoots), bajra (stem).

Status.—A serious pest to young canes, in the first three months of their growth. Less injurious in old canes, but sometimes abundant. In maize, rarely destructive to the cob and stem. In juari a very serious pest occasionally, destroying the stems of the old plants. One of the most important general pests of India.

Larva.—$\frac{3}{4}$ inch. White with dark specks. Head black, prothoracic shield black. Body whitish, with regular dark tubercles on each segment, bearing hairs. Purple brown pigment arranged in irregular bands.

PYRALIDÆ—(*contd.*)

122. CHILO AURICILIA. Ddgn. Journ., Bo. Nat. Hist. Soc., XV, p. 405.
Ind. Ins. Pests, p. 136.

20—23 m. m. Distinct from *C. simplex* Butl. by the form of the male antennæ ("flattened by coalescing lamellæ separated distinctly"), and by the metallic spots on the forewing. Male smaller and darker. The insect will be accurately recognized only from good unrubbed specimens of the moths, which must be reared. It is probably a hill species which wanders into the sub-montane tracts, and is likely to be found in the Assam and Ganges valley.

Distribution.—Known from Behar where it was first reared by Mr. M. Mackenzie, and from Sikkim, Bhutan and Cuttack.

Life History.—Generally similar to *C. simplex.* In cane, the larvæ and pupæ are indistinguishable from this species.

Food Plants.—Cane, rice.

Status.—A minor pest of cane, which may replace *C. simplex.* Canes may be full of this insect and the two species of *Chilo* occur together in varying numbers.

Larva.—Like *C. simplex.*

PYRALIDÆ—(*contd.*)

133. ANCYLOLOMIA CHRYSOGRAFFELLA. Koll. Hügels Kashmir, IV, p. 294.
Hampson, Fauna of India, Moths, IV, p. 33 (fig. i).

Expanse, male 20—30, female 30—40 m. m. Brownish ochreous. The silvery cilia and fasciæ, the silvery sub-marginal line and dark specks on the marginal white band make the moth easily recognizable in the field. Male antennæ laminated.

Distribution.—South Africa, Aden, Japan, China, Formosa, Penang. Throughout India, Burma, Ceylon.

Life History.—Larva lives in rolled leaf, the pupa on the leaf under the fold; the moth comes to light.

Food Plants.—Rice, probably grasses.

Status.—A minor pest of rice, likely to be occasionally abundant. One of the many casual pests of rice, occurring in any part of India sporadically.

PYRALIDÆ—(*contd.*)

121. SCIRPOPHAGA AURIFLUA.—Zell. Mon. Chil. and Cramb., p. 2.
Hampson, Fauna of India, Moths, IV, p. 46 (fig. i).
Indian Museum Notes, V, p. 174 (fig. l, p. i).
Ind. Ins. Pests, p. 130 (fig. l, p. i).

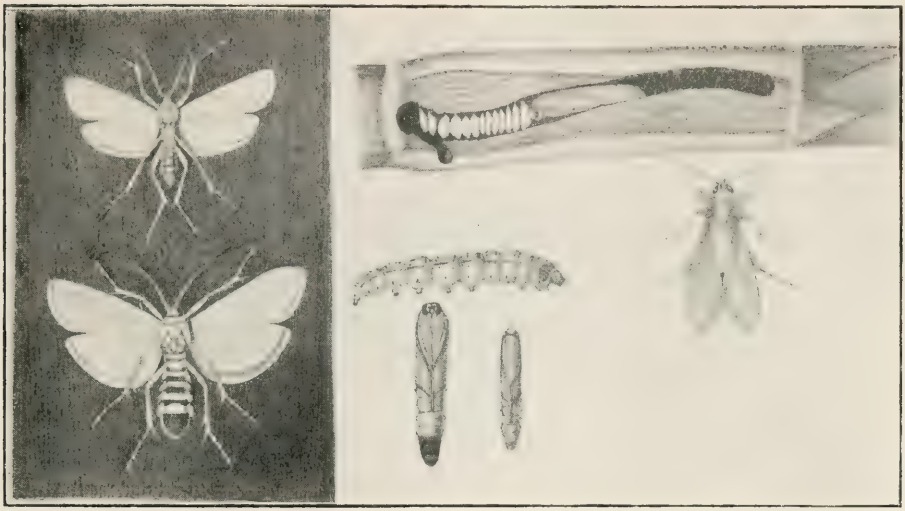


FIG. 59. SCIRPOPHAGA AURIFLUA.
Larva, pupa in cane, male and female pupa and moth.

Expanse, male 28—30, female 24—50 m. m. Pure white, anal tuft buff, or red outwardly in *Var. intacta*. Moth recognizable by its venation, projecting frons and long palpi; superficially by its pure white wings and buff or red anal tuft.

Distribution.—Congo, Shanghai, Borneo, Java. In India, Burma and Ceylon, throughout the plains and in Sikkim, Bhutan and Kangra.

Life History.—Eggs in clusters covered in hair. The larva is a borer, always eating down to the growing point and into the cane. Pupa in the cane, the exit hole closed by diaphragms spun across. Hibernates as a larva or pupa from November to early March.

Food Plants.—Cane, munj grass.

Status.—A serious pest to cane in Behar and Oudh. Not known as a pest from other parts of India. One of the more important cane pests.

PYRALIDÆ—(*contd.*)

145. SCIRPOPHAGA MONOSTIGMA.—Zell. Mon. Chil and Cramb. 3.
Hampson, Fauna of India, Moths, IV, p. 46.

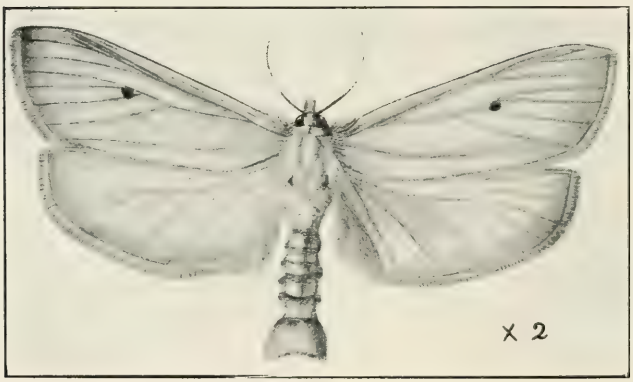


FIG. 60. SCIRPOPHAGA MONOSTIGMA.

Expanse, 22—30 m. m. Distinct from *S. auriflua* by the black spot in the forewing.

Distribution.—Campbellpur, Bhutan, Behar and probably other submontane localities. Probably a hill form that does not spread far into the plains.

Life History.—Similar to that of *S. auriflua* so far as known.

Food Plants.—Cane and probably grasses.

Status.—A minor pest, found with *S. auriflua* and not important.

PYRALIDÆ—(*contd.*)

146. ANERASTIA ABLUTELLA.—Zell. Ins. 1839, p. 177.
Hampson, Fauna of India, Moths, IV, p. 56.
Ind. Ins. Pests, p. 136.

Expanse, 13—18 m. m. Ochreous; forewing slightly irrorated with fuscous. Hindwing white. Moth distinct in venation and in the projection of the frons. Not easily recognized.

Distribution.—Mediterranean subregion, Punjab, Behar.

Life History.—Only partly known. Larva a borer in the cane, green in colour, pupa in the ground. Apparently only two broods in the year, with long period of hibernation during the rains and cold weather (M. Mackenzie).

Food Plant.—Cane.

Status.—A local pest to young sugarcane. Might spread and become serious and may already have a wide distribution.

Larva.—1 inch. Bright green.

PYRALIDÆ.—(*contd.*)

149. POLYOCHA SACCHARELLA.—Ddgn. Journ. Bo. Nat. Hist. Soc., XVI, p. 405.
Ind. Ins. Pests, p. 136.

Expanse, 25—34 m. m. Distinct from Anerastia in venation and in the palpi. Superficially like *A. ablutella*. Uniform pale ochreous brown. Forewing of male slightly suffused with fuscous. Hindwing white.

Distribution.—Described from Behar, where it was found by Mr. Mackenzie.

Life History.—Typically a borer in the cane stool. Larva white, pupa in the roots. Hibernation as a larva from November to April (M. Mackenzie).

Food Plant.—Cane.

Status.—A serious local pest to cane. Probably extends into the United Provinces and Bengal, hitherto not found.

PYRALIDÆ—(*contd.*)

2. EUZOPHERA PERTICELLA.—Rag. Nouv. Gen., p. 32. Hampson, Fauna of India, Moths, IV, p. 73 (fig. i). Indian Insect Pests, p. 166.

Expanse, male 26, female 32 m. m. Forewing pale rufous, suffused with grey ; a strongly dentate black line, a fuscous suffusion near apex and a marginal series of black specks. Hindwing white. Moth recognizable superficially by the line on the forewing. Easily distinct from other pests.

Distribution.—Calcutta, Nilgiris, Gujarat, Central Provinces, Behar, Ceylon.

Life History.—Larva a borer in lower part of stem. Pupa in cocoon in stem. Hibernation doubtful.

Food Plant.—Brinjal (*Solanum melongena*).

Status.—A serious local pest. Apparently not widely scattered as a pest and of uncertain distribution in India.

Larva —$\frac{3}{4}$ inch. White, head brown, short hairs.

PYRALIDÆ—(*contd.*)

ETIELLA ZINCKENELLA.—Treitschke. Schmett Eur. CXI, p. 201.
Hampson, F. Ind. Moths, IV, p. 108.
Indian Museum Notes, III, p. 98.

Expanse, 18—30 m. m. Pale rufous. Forewing grey-brown with a white costal fascia and a transverse rufous bar, hindwing with brown suffusions and lines. Distinct from all the genus by the male antennæ. Moth superficially fairly distinct.

Distribution.—Universal. In India, in plains and hills widely scattered.

Life History.—Larva a pod borer.

Food Plants.—Pods of khesari (*Lathyrus sativus*), Sann Hemp (*Crotalaria*), Peas and Saidi beans.

Status.—Minor pest, sporadic.

Larva.—Green with a red dorsal band.

PYRALIDÆ—(*contd.*)

80. PHYCITA INFUSELLA.—Meyr.
Indian Insect Pests, p. 99 (fig. l, p. i).

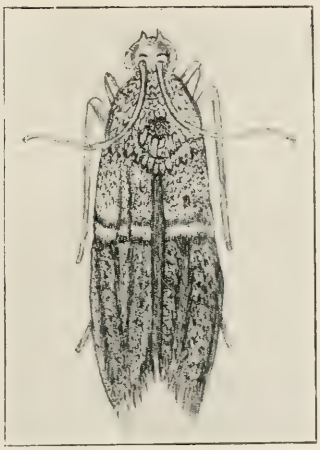


FIG. 61. PHYCITA INFUSELLA. ×5.

Head, thorax and basal half of wing light grey-brown, apical half darker.

Distribution.—In India, general in the plains.

Life History.—Egg singly on leaf. Larva in webbed leaves of top shoots, pupa in same. No hibernation in plains, throughout the year.

Food Plant.—Cotton.

Status.—Minor pest.

Larva.—$\frac{2}{3}$ inch. Green. Head black. Prothorax dark. Body green with fine waved lines of brown pigment. Dark tubercles bearing short hairs.

PYRALIDÆ—(*contd.*)

NYMPHULA FLUCTUOSALIS.—Zell. K. Vet. Ak. Hindl. 1852, p. 27.
Hampson, F. Ind. Moths, IV, p. 193 (fig. i).
Wood-Mason, Rice Pest of Burma (fig. l).

Expanse, 16—20 m. m. White, with black markings ; wings white, with fulvous black bands curved across both wings. The form of the palpi and the venation distinguish the genus.

Distribution.—Tropical and sub-tropical zones. In India, a plain and hill form.

Life History.—Wood-Mason's account probably refers to this species : Larva semi-aquatic in a case of rice leaves. Pupa semi-aquatic.

Food Plant.—Rice.

Status.—A somewhat serious pest in Burma and Assam. Locally ranks as a major pest and dependent upon very wet conditions.

PYRALIDÆ—(*contd.*)

38. NYMPHULA DEPUNCTALIS.—Guen. Delt. et Pyr., p. 274.
Hampson, Fauna of India, Moths, IV, p. 195.
Indian Insect Pest, p. 121.

Expanse, 16 m. m. White, forewing with a dark spot in cell, two dark discocellular spots. Oblique fulvous band across wing and a sub-marginal fulvous band. Hindwing with two fulvous bands, both wings with a crenulate fulvous line inside margin and a marginal series of specks.

Distribution.—Throughout India, Burma and Ceylon. Java, Australia.

Biology.—Eggs singly on plant. Larva semi-aquatic in case of rolled leaf, active. Pupa in rolled leaf. Found during rains.

Food Plant.—Rice.

Status.—Serious local pest.

Larva.—$\frac{1}{2}$ inch. Greenish, with tubular processes on each segment.

PYRALIDÆ—(*contd.*)

123. ZINCKENIA FASCIALIS.—Cram. Pap. Exot., IV, p. 398
Hampson, Fauna of India, Moths, IV, p. 262 (fig. i).
(*Hymenia recurvalis*). Indian Museum Notes, IV, p. 16 (fig. l, p. i).
Ind. Ins. Pests, p. 182 (fig. i).

FIG. 62. ZINCKENIA FASCIALIS. × 3.

Expanse, 24 m. m. Dark brown; forewing with a black edged white band from the inner margin, a white band from the costal margin near apex. Hindwing with a broad white band from costa to near anal angle. Cilia black, white below apex and at middle. Like Z. *perspectalis* but browner and with no antemedial band.

Distribution.—Neotropical, Oriental, Ethiopian, Australian and Palæarctic Asia. In India, general in hills and plains.

Life History.—Larva on leaves, typical leaf-eating pyralid larva. Pupa in rolled leaf. Hibernation doubtful, moth appears in March, about six broods before the winter.

Food Plants.—Amaranthus, beetroot, maize. Probably many wild plants.

Status.—Chiefly as a pest on irrigated vegetable crops in the hot weather, in company with other larvæ. Occasional pest in rains. A sporadic minor pest.

Larva.—$\frac{5}{8}$ inch. Green, two lateral white streaks. Crescent shaped black spots on meso and meta-thorax, below lateral lines.

Pyralidæ—(*contd.*)

48. Cnaphalocrocis medinalis. Guen. Delt et Pyr., p. 201. Hampson, Fauna of India, Moths, IV, p. 275 (Fig. i). Ind. Ins. Pests, p. 122.

Expanse, 20 mm. Ochreous, the forewing fuscous on costa and outer margin, with two fine fuscous lines. Hindwing with one fuscous line and an outer fuscous suffusion.

Distribution.—Japan, Oriental and Australian regions. In India, in plains.

Life History.—Larva leaf rolling, folding over the narrow blade. Pupa on the leaf. Found so far only in the rains.

Food Plants.—Rice and probably grasses.

Status.—Sporadic minor pest, locally injurious.

PYRALIDÆ—(*contd.*)

210. MARASMIA TRAPEZALIS. Guen. Delt et Pyr., p. 200.
Hampson, Fauna of India, Moths, IV, p. 277 (Fig. i).
Indian Museum Notes, V, p. 141 (Fig. i).
Indian Insect Pests, p.138.

FIG. 63. MARASMIA TRAPEZALIS.

Expanse, 22 mm. Pale ochreous suffused with brown. Both wings suffused outwardly with fuscous and with oblique fuscous lines. Cilia pale, dark marginal line and line through the cilia. Wing markings recognizable. Palpi and venation distinguish it from other genera and species.

Distribution.—Neotropical, Ethiopian, Oriental and Australian regions. In India, Himalayan and Ganges valley.

Life History.—Larva a leaf-roller, living in rolled up blade of leaf. Pupa in rolled up leaf. Hibernation doubtful; found only in rains. Not more than three broods.

Food Plants.—Maize, juari, bajra, cane.

Status.—Minor pest, not seriously injurious and of regular occurrence.

Larva.—$\frac{4}{5}$ inch. Green, head and prothoracic shield brown, short hairs and tubercles.

Pyralidæ—(*contd.*)

116. Dichocrocis punctiferalis.—Guen. Delt et Pyr., p. 320.
Hmpsn. F. Ind. Moths, IV, p. 307 (Fig. i).
(*Conogethes punctiferalis*) Indian Museum Notes, III, 6, p. 17 (Fig. l, p. i).
Indian Insect Pests, p. 159.

Expanse, 24—32 mm. Yellow spotted with black. Both wings with black spots. Recognizable in field from the orange colour and black spots.

Distribution.—Japan, China, Malayan Sub-region, Australia. India, Burma and Ceylon. In plains and hills.

Life History.—Typically the larva is a pod-borer, pupating in a silken covering in the pod. Throughout the year.

Food Plants.—Pods of castor, sunflower heads; cacao pods in Ceylon (Green).

Status.—Minor pest of regular occurrence in varying numbers. Probably very local, depending upon food-supply.

PYRALIDÆ—(*contd.*)

37. SYLEPTA DEROGATA.—Fabr. Syst. Ent., p. 641.
(*Multilinealis*) Guen. Delt et Pyr., p. 337.
(*Multilinealis*) Hmpsn. F. Ind., Moths, IV, p. 334.
(*Synclera Multilinealis*) Indian Museum Notes, IV, V (Fig. i).
(*Multilinealis*) Haymann, Report of Cawnpore Farm, 1904, p. 20.
Indian Insect Pests, p. 96 (Fig. i).

Expanse, 28—40 mm. Yellowish white; both wings with brown lines and markings. Markings distinct and recognizable.

Distribution.—West Africa, East Siberia, Japan, China, Malayan Sub-region, India, Burma, Ceylon. In India, universal in plains and in hills.

Life History.—Egg laid singly on leaf. Larva a leaf-roller, living in rolled up leaves or simply folding over the leaf. Pupa in leaf roll or soil. Active in rains up to November, and in hot weather if food available. Hibernation from November, about five broods normally.

Food Plants.—Cotton, bhindi, hollyhock.

Larva.—1 inch. Transparent shiny green. Head and prothorax brown.

Pyralidæ—(*contd.*)

112. Glyphodes indica.—Saund. Trans. Ent. Soc., 1851, p. 163.
Hmpsn. F. Ind., Moths, IV, p. 360.
(*Eudioptes*) Indian Museum Notes, III, p. 136 (Fig. l, p. i).
Indian Insect Pests, p. 165 (Fig. i).

Fig. 64. Glyphodes indica. ×2.

Expanse, 24—28 mm. Abdomen with anal tuft of long spatulate scales. Forewing nearly white with broad black fascia on costal and outer margin. Hindwing pearly with marginal black band. The anal tuft distinguishes it from *unionalis* and others of the genus. Recognizable in field flying by day on its food plants.

Distribution.—Oriental, Ethiopian, Australian regions. In India, hills and plains.

Life History.—Larva on leaf, under webbing. Pupa on leaf. Occurrence doubtful, probably throughout the year.

Food Plants.—Cucurbitaceous plants generally.

Status.—Minor pest of vegetable crops.

Larva.—1 inch. Transparent green. A stripe of white on each side of middle line ; a minute black spot on thoracic one and two below white stripe. Few long slender colourless hairs on each segment.

Pyralidæ—(*contd.*)

109. Leucinodes orbonalis.—Guen. Delt et Pyr., p. 223.
Hampson, Fauna of India, Moths, IV, p. 370 (Fig. i).
Indian Museum Notes, III, p. 110 (Fig. l, p. i).
Indian Insect Pests, p. 166 (Fig. l, i).

Fig. 65. Leucinodes orbonalis.

Expanse, 24 mm. White, forewing with fulvous, black, and ferruginous markings. Hindwing white, with black lines and specks. The only common species of the genus. Easily recognizable in the field from the markings.

Distribution.—South Africa, Java, India, Burma and Ceylon. In India, plains and hills.

Life History.—Essentially a fruit-boring larva, living on the seed and pulp. Pupa in grey silk cocoon on leaf. Hibernation does not occur in the plains, and the insect is active throughout the year. Extreme cold in plains makes larva dormant, but this rarely occurs.

Food Plants.—Brinjal.

Status.—A minor pest of regular occurrence, responsible for a large aggregate damage.

Larva.—$\frac{3}{8}$ inch. Flesh colour. Head brown, prothorax with brown shield. Few short hairs on round dark spots.

PYRALIDÆ—(*contd.*)

196. CROCIDOLOMIA BINOTALIS.—Zell. K. Vet. Ak., Handl. 1852, p. 66.
Hampson, Fauna of India, Moths, IV, p. 372.

Pale ochreous, forewing suffused with fuscous and ferruginous, with black lines and specks, and dark-edged white spots. Hindwing white, outwardly suffused with fuscous. Male with costal tuft of black hair. Not readily distinguished in the field, likely to be confused with *C. suffusalis*.

Distribution.—South Africa, Formosa, Java, Australia. India, Burma, Ceylon. Hill and plain form.

Life History.—Leaf-eating caterpillar, under webbing. Occurrence chiefly in hot weather on vegetable crops. Hibernation uncertain.

Food Plants.—Cabbage, halim (*Lepidium sativum*) and other cruciferous plants.

Status.—Minor pest of hot weather irrigated crops.

Larva.—$\frac{3}{4}$ inch. Green. A medial and a lateral line of yellow white. Short hairs on dark tubercles.

PYRALIDÆ—(*contd.*)

231. MARUCA TESTULALIS.—Geyer. Hübn. Samml. Exot. Schmett, IV, p. 12.
Hampson, Fauna of India, Moths, IV, p. 393 (Fig. i).
Indian Museum Notes, IV, p. 13 (Fig. i).
Indian Insect Pests, p. 149 (Fig. i).

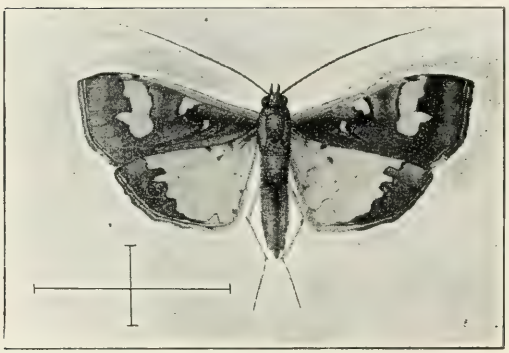


FIG. 66. MARUCA TESTULALIS.

Expanse, 26—30 mm. Fuscous brown. Forewing with a conspicuous black-edged white spot. Hindwing white, with a marginal fuscous band. Easily recognized from other pests by its markings.

Distribution.—Neotropical and Ethiopian, Japan, Oriental and Australian regions. In India, hills and plains.

Life History.—Larva a pod-borer, eating pods of leguminous plants, which it enters. Does not feed from outside. Pupa in the pod. Found in rains. Hibernation uncertain.

Food Plants.—Mung, moth tur. Probably wild leguminosæ.

Status.—Minor pest little known as yet.

Larva.—$\frac{1}{2}$ inch. Green, sometimes with a pink tinge. No lines. Small dark tubercles bearing hairs.

Pyralidæ—(*contd.*)

234. Pachyzancla stultalis.—Wlk. Cat. XVIII, p. 669. Hampson, Fauna of India, Moths, IV, p. 405.

Expanse, 22—28 mm. Ochreous, suffused slightly with fuscous. An inner and outer fuscous line on both wings, the latter waved and dentate with black specks inside, on forewing. Forewing with a submarginal series of black specks. Hindwing with a double dark marginal line.

Distribution.—China, Andamans, Sumatra, Java, Borneo, Celebes, Australia. India, Burma and Ceylon. In plains.

Life History.—Larva webs leaves and lives within. Pupa on the plant. Found in rains, hibernation uncertain.

Food Plant.—Soy beans and probably wild leguminous weeds.

Status.—Minor pest, as yet little known. Probably one of the common sporadic pests.

Larva.—$\frac{2}{3}$ inch. Head and thorax yellow, abdomen green. A black spot on prothorax laterally. Minute hairs.

PYRALIDÆ—(*concld.*)

111. ANTIGASTRA CATALAUNALIS.—Dup. Lep. France, VIII, p. 330.
Hampson, Fauna of India, Moths, IV, p. 412 (Fig. i).
Indian Insect Pests, p. 161.

Expanse, 20 mm. Ochreous, forewing with the veins orange red, the marginal area orange red, cilia black at base, white at tips. Hindwing ochreous, reddish at outer edge. Form and colour easily distinguishes the insect in the field. No other Indian species.

Distribution.—Europe, Syria, Aden, East and West Africa, India, Burma, Ceylon. Common in the plains.

Life History.—Larva webbing leaves together and feeding within. Pupa on the plant. Active from April to November, depending upon food-supply. Usually at least four broods in the rains.

Food Plants.—Til (*Sesamum indicum*).

Status.—A minor pest of general occurrence and some aggregate importance.

Larva.—$\frac{1}{2}$ inch. Nearly white, a touch of creamy green, black speckled. Head black, prothorax dark above. Meso and meta-thorax, two dorsal tubercles with hairs. Abdomen three dorsal tubercles, with hairs, on each segment.

PTEROPHORIDÆ.

72. EXELASTIS ATOMOSA.—Wals. Proc. Zool. Soc. Lond., 1885, p. 885.
(*E. parasita*) Indian Insect Pests, p. 140 (Fig. 1, p. i).

FIG. 67. EXELASTIS ATOMOSA.
Larva ×3 and bunch of spines.

Distribution.—General in Gujarat, Central Provinces, Behar, Madras and probably throughout the plains.

Life History.—Egg singly on pods. Larva feeding on seeds of leguminous plants not entering the pod. Colour cryptic. Pupa on pod, naked, colour protective. Hibernation does not occur; found principally in cold weather.

FIG. 68. EXELASTIS ATOMOSA.—Resting attitude.

Food Plants.—Tur (*Cajanus indicus*) and Kulthi (*Dolichos lab-lab*).
Status.—Serious local pest, depending upon area sown in crop.
Larva.—$\frac{1}{2}$ inch. Green, or green and brown, pubescent. Each segment is clothed in hairs and capitate spines, the latter radiate from regular points or single. Median dorsal line with a slight ridge.

PTEROPHORIDÆ—(*contd.*)

279. SPHENARCHES CAFFER.—Zell. Hand. Kong. Svensk Vet-Ak, 1852, 118.
Indian Museum Notes, II. (Fig. l, p. i).

Expanse, 16 mm. Ochreous brown, wings with lighter bands and dark spots.

Distribution.—Australia, Africa, Japan, Ceylon, Burma. India, Gujarat, Central Provinces, Behar.

Biology.—Egg singly on leaf, larva and pupa exposed on plant. No hibernation in plains, active throughout the year.

Food Plants.—Cultivated cucurbitaceæ. Tur (*Cajanus indicus*). Kulthi (*Dolichos lab-lab*).

Status.—Minor pest.

Larva.—Like *Exelastis atomosa.*

TORTRICIDÆ.

143. Eucelis critica.—Meyr. Journ. Bo. Nat. Hist. Soc., XVI, p. 587.
Indian Insect Pests, p. 143.

Expanse, 12—14 mm. Grey tinged with fuscous; forewing with fuscous striæ, four black dots and a silvery transverse mark, the apex darker, the cilia pale.

Distribution.—Described from Surat. Found in Gujarat generally, Behar, Nagpur.

Life History.—Larva in webbed leaves of top shoots. Pupa in same. Hibernation occurs. Found only from July to October.

Food Plants.—Tur (*Cajanus indicus*).

Status.—Minor pest of regular occurrence.

Larva.—$\frac{1}{3}$ inch. Orange brown, slightly compressed. Head brown, body with short hairs.

TORTRICIDÆ—(*contd.*)

157. LASPEYRESIA TRICENTRA.—Meyr. Jo. Bo. Nat. Hist. Soc., XVII, p. 734.

Expanse, 11—13 mm. Fuscous, wings irrorated with greyish ochreous, forewing with oblique fuscous costal striæ and three dark points touching the posterior margin.

Distribution.—India, Ceylon, general in the plains.

Life History.—Larva boring in stems. Pupa in stem. Hibernation uncertain.

Food Plants.—Sann Hemp.

Status.—Minor pest.

TINEIDÆ.

74. GELECHIA GOSSYPIELLA.—Saund. Trans. Ent. Soc. Lond., III, p. 284.
Meyr. Jo. Bo. Nat. Hist. Soc., XVI, p. 592.
Haymann, Report of Cawnpore Farm, 1904, p. 17.
Indian Insect Pests, p. 93 (Fig. l, p. i).
Agric. Journ. Ind., I, p. 54 (Fig. l, p. i).

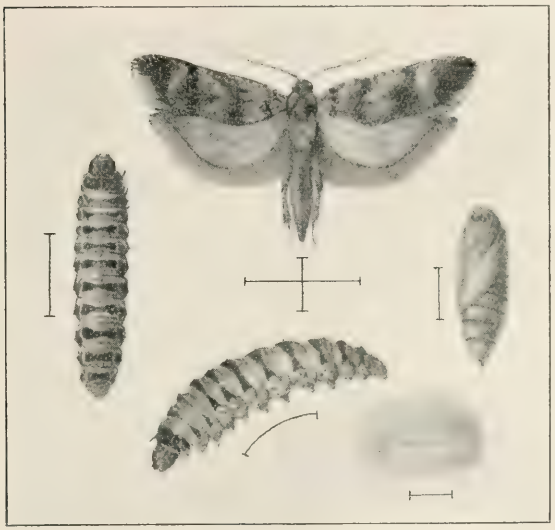


FIG. 69. GELECHIA GOSSYPIELLA.

Expanse, 18 mm. Palpi upturned, sickle shaped. Dark brownish ochreous, the forewing with darker suffusions. Hindwing grey, suffused with fuscous at the apex.

Distribution.—Ceylon. In India, general in cotton districts. Bombay, Sind, Central Provinces, Madras, Bengal, United Provinces, Punjab, Burma (Myitkyina). Probably Straits Settlements and German East Africa.

Biology.—Egg singly on bract. Larva feeds in oily seeds. Pupa in light cocoon in soil or on plant. Hibernation as larva in seed in colder part of plains only. About six broods yearly where food is available.

Food Plant.—Cotton.

Status.—Major pest of cotton, of regular and general occurrence.

Larva.—$\frac{2}{3}$ inch. Smooth, pink or white. Head and prothoracic shield brown. Thorax and abdomen whitish with broad median and lateral pink blotches.

TINEIDÆ—(*contd.*)

79. GNORIMOSCHEMA HELIOPA. LOW.

Meyr. Journ. Bo. Nat. Hist. Soc., XVI, p. 592.
Indian Insect Pests, p. 156.

Expanse, 14 mm. Ochreous brown, the forewings with darker fasciæ, the hindwing grey.

Distribution.—Australia, Ceylon. In India, Gujarat, Rungpur, Behar.

Biology.—Larva living in green stems, causing a gall-like swelling. Pupa in the gall. Hibernation does not occur.

Food Plant.—Tobacco.

Status.—A serious pest to tobacco, of regular occurrence.

Larva.—$\frac{1}{3}$ inch. White. Head and prothoracic shield dark. A subdorsal dark tubercle on each segment.

TINEIDÆ—(*contd.*)

3. PLUTELLA MACULIPENNIS. Curt.

Indian Museum Notes, IV, 196 (Fig. l, p. i).
Indian Insect Pests, p. 152 (Fig. l, p. i).

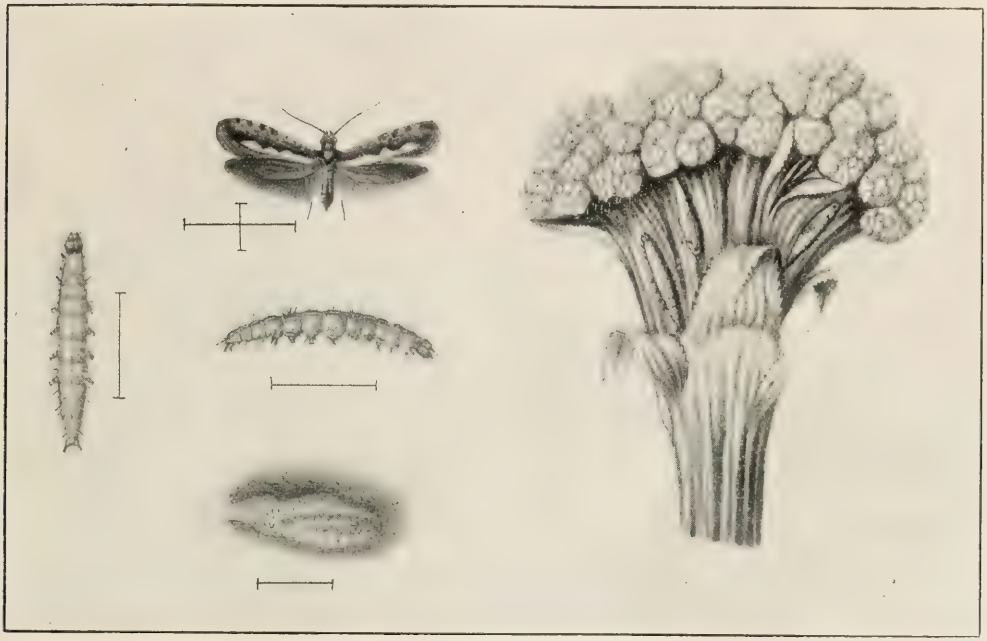


FIG. 69. PLUTELLA MACULIPENNIS.

The wing markings are characteristic, especially when wings are folded.

Distribution.—Europe, Australia. In India, throughout the plains. The Diamond back moth of England and Ireland. The cabbage moth of Australia, Natal, Cape Colony, United States of America.

Life History.—Egg singly on leaf. Larva feeds openly on leaves. Pupa in light net cocoon on leaf. No hibernation in plains.

Food Plants.—Cabbage, rape, mustard, etc. Most cultivated *Cruciferæ.*

Status.—Minor pest of field crops, more important as a pest of market gardens.

Larva.—$\frac{1}{3}$ inch. Green. Head brown, prothorax above brown with black specks. Body green, with red tinge ; dark hairs on light tubercles.

TINEIDÆ—(*concld.*)

272. ANACAMPSIS NERTERIA.—Meyr. Jo. Bo. Nat. Hist. Soc. XVII, p. 139.

Expanse, 10—11 mm. A fuscous moth, with a bronzy tinge; forewings fuscous, bronze tinged, the cilia fuscous; the hindwings and cilia grey.

Distribution.—Ceylon, South India.

Biology.—Egg on leaf singly. Larva between webbed leaf. Throughout the year.

Food Plants.—Groundnut (*Arachis hypogea*).

Status.—Serious local pest.

Larva.—"Dull greenish. Head and prothoracic shield dark brown; spots black." (Green.)

TRYPETIDÆ.

129. Dacus Ferrugineus.—Fabr. Ent. Syst. IV.
Indian Museum Notes, II, III, IV (Fig., p. i).
Indian Insect Pests, p. 170 (Fig., p i).

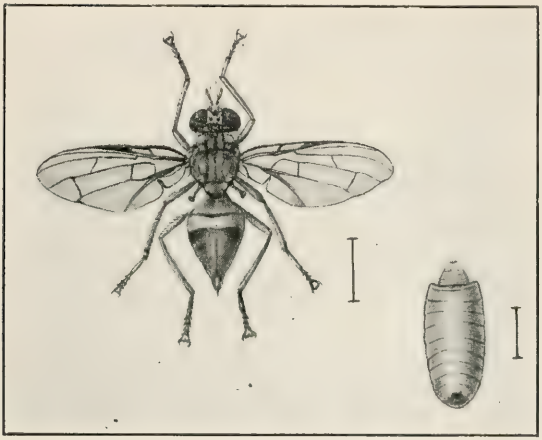


Fig. 71. Dacus ferrugineus.

Red-brown, the thorax marked with black and yellow, the abdomen with yellow. Wings unbanded.

Distribution.—Bengal, United Provinces, Kanara.

Biology.—Egg in skin of fruit. Larva in fruit, pupa in soil. Hibernation in cold months only.

Food Plants.—Mango, Cucurbitaceous fruits, Ak (*Calotropis sp.*).

Status.—Local pest, sporadically abundant.

TRYPETIDÆ—(*contd.*)

130. DACUS CUCURBITÆ. Coq.

Red-brown, the thorax marked with yellow, the abdomen with a black and a white band. Wing with a brown band and apical blotch.

Distribution.—Nasik, Pusa, Hathwa, Surat, Umballa. Probably throughout India.

Biology.—Egg in skin of fruit. Larva in fleshy fruits. Pupa in soil. Hibernation in cold months. Found in hot weather and rains.

Food Plants.—Fruits of Cucurbitaceæ.

Status.—Sporadic pest, occasionally serious.

TRYPETIDÆ—(*concld.*)

218. CARPOMYIA PARDALINA.—Big. Indian Museum Notes, II, 51.
Indian Museum Notes, II, III (Fig. i).
Indian Insect Pests, p. 171 (Fig. l, p. i).

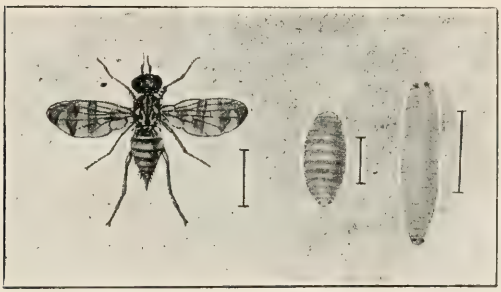


FIG. 72. CARPOMYIA PARDALINA.
Larva, Pupa, Imago.

Expanse, 11 mm. Wings with three yellowish bands. Colour light brown, thorax with black and white spots.

Distribution.—Baluchistan, Punjab.

Biology.—Egg in skin of fruit. Larva in fleshy fruits. Pupa in soil. Hibernation from September to April (Cleghorn), as pupa. One or two broods, dependent upon food-supply.

Food Plants.—Melon.

Status.—Serious local pest, of regular occurrence.

PENTATOMIDÆ.

223. NEZARA VIRIDULA.—Linn. Syst. Nat. Ed. X, p. 444.
Dist. F. Ind. Rhynch. I, p. 220 (Fig. i).
Indian Museum Notes, I, III.
Indian Insect Pests, p. 168 (Fig. i).

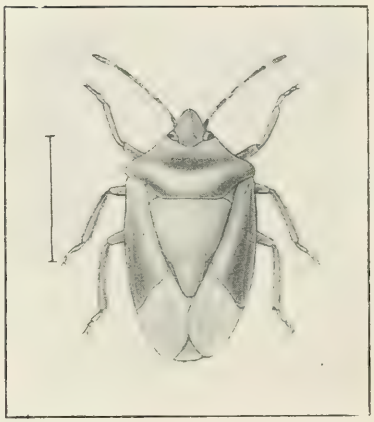


FIG. 73. NEZARA VIRIDULA.

Length, 12—16 mm. Green, rarely with buff markings on head and prothorax. Antennæ brown towards apex.

Distribution.—Palæarctic, Nearctic, Ethiopian regions : part of subtropical, Oriental and Australian regions. Throughout India, but not general. Hills and plains.

Biology.—Eggs on plants, nymph and adult on plants. Found in rains and probably throughout the year. Hibernation doubtful.

Food Plants.—Potato, castor, juar heads, rice ear.

Status.—Minor pest.

Pentatomidæ—(*contd.*)

224. Dolycoris indicus.—Stol., En. Hem. V, p. 76.
Dist. F. Ind. Rhynch. I, p. 189.
Agonoscelis nubila. Indian Museum Notes, V, pp. 143, 154 (Fig. i).
Agonocelis nubila. Indian Insect Pests, p. 233.

Fig. 74. Dolycoris indicus.

Length, 10—11 mm. Ochraceous with black fasciæ and spots. The edge of the abdomen visible from above (Cf. *Agonoscelis*).

Distribution.—Nagas, Calcutta, Mysore, Behar, Deccan, Surat. Probably general in the plains.

Biology.—Nymph and imago on plants, in flowering heads or young grain. Found throughout the year. Hibernation as adult, æstivation as adult ; dependent upon food-supply.

Food Plants.—Maize, juar, small millets.

Status.—Minor pest of developing grain. Local and sporadic.

PENTATOMIDÆ—(*contd.*)

169. BAGRADA PICTA.—Fabr., Syst. Ent., p. 715.
Dist. F. Ind. Rhynch. I, p. 193 (Fig. i).
(*Apines concinna*). Indian Museum Notes, II, V.
Indian Insect Pests, p. 233 (Fig. i).

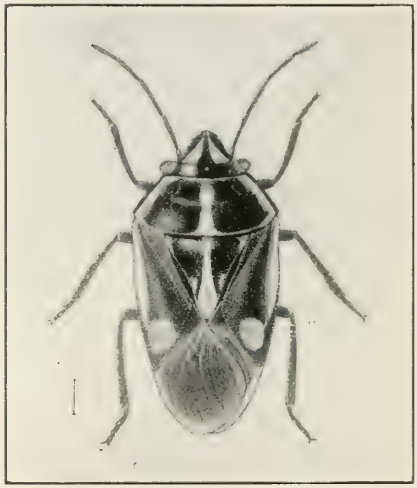


FIG. 75. BAGRADA PICTA.

Length, 5—7 mm. Black with ochraceous and red markings.

Distribution.—Hardwar, Calcutta, Tirhoot, Manipur, Bombay, Ceylon, Nagpur.

Biology.—Eggs on leaves, nymph and imago on plant, active. Found throughout the year. Imago survives period of scarcity.

Food Plants.—Mustard, rape, and other cruciferous plants.

Status.—Minor pest, sporadic.

PENTATOMIDÆ—(*concld.*)

207. ANTESTIA CRUCIATA.—Fabr., Syst. Ent., p. 714.
Dist. F. Ind. Rhynch. I, p. 185.
Indian Insect Pests, p. 235.

Length, 7—9 mm. Green to yellow, much spotted with black.

Distribution.—Sikhim, Calcutta, Bombay, Nilgiris, Ceylon, Tenasserim, Malay Archipelago.

Biology.—Imago flying in coffee.

Food Plants.—Coffee berries.

Status.—Minor pest.

COREIDÆ.

266. CLAVIGRALLA HORRENS.—Dohrn., Stett. Ent. Zeit., XXI, p. 403.
Distant, F. Ind. Rhynchota, I, p. 402.

Length, 7 mm. Brownish marked with chestnut. Pronotum spined; femora swollen at the apex.

Distribution.—Bombay, Ceylon, Assam, Burma, Nagpur.

Biology.—Eggs laid on leaves. Nymphs and imago active. No hibernation in plains.

Food Plants.—Tur (*Cajanus indicus*), cultivated leguminosæ.

Status.—Minor pest, local and sporadic.

COREIDÆ—(*contd.*)

103. · LEPTOCORISA VARICORNIS.—Fabr. Syst. Rhyng., p. 260.
Distant, F. Ind. Rhynch. I, 409.
Atkinson, Indian Museum Notes, I, p. 1 (Fig. i).
L. *acuta*. Indian Museum Notes, I—V.
Indian Insect Pests, p. 116 (Fig. e, i).

FIG. 76. LEPTOCORISA VARICORNIS. ×2.

Length, 15—17 mm. Green to ochraceous, apical half of second, third and fourth antennal joints darker.

Distribution.—China, Burma, Malay Peninsula and Archipelago. General in India in hills and plains.

Biology.—Eggs on leaves, nymphs and imago in long grass, on flowering grasses and grain heads. Hibernation as an imago in dense vegetation. Found chiefly in rains, reproduction dependent upon food-supply.

Food Plants.—Rice, small millets, flowering grasses.

Status.—Minor pest, rarely becoming serious and abundant

LYGAEIDÆ.

5. OXYCARAENUS LÆTUS.—Kby. J. Linn. Soc., Zool. XXIV, p. 102.
Dist., F. Ind. Rhynch. II, p. 43 (Fig. i).
(*Lugubris*) Indian Museum Notes, II, III (Fig. i).
(*Lugubris*) Haymann, Report of Cawnpore Farm, 1904, p. 19.
Indian Insect Pests, p. 107 (Fig. i).

FIG. 77. OXYCARAENUS LÆTUS. (From Distant).

Length, 4 mm. Dull ash colour, the wings pale grey. Likely to be confused with *O. lugubris*. Motsch.

Distribution.—Calcutta, Ceylon, Burma. General in the plains of Punjab, United Provinces, Bengal, Central Provinces, Bombay Presidency.

Biology.—Eggs in seed capsules. Nymphs and imago in seed capsules. Hibernation as adult in colder parts of India.

Food Plants.—Bhindi, cotton, abutelon, and other garden *Malvaceæ*.

Status.—Rarely serious, usually a general and regular minor pest.

PYRRHOCORIDÆ.

69. DYSDERCUS CINGULATUS.—Fabr. Syst. Ent., p. 719.
Dist., F. Ind. Rhynch. II, p. 119 (Fig. i).
Indian Museum Notes, II, III (Fig. not this species).
Haymann, Report of Cawnpore Farm, 1904, p. 18.
Indian Insect Pests, p. 104 (Fig. i).

FIG. 78.
DYSDERCUS CINGULATUS.
(From Distant).

Length, 9—16 mm. Ochraceous to red; the wing with a black discal spot and membrane; white bands below and on pronotum.

Distribution.—Queensland, Malay Archipelago and Peninsula. Burma, Ceylon; in India, general in hills and plains.

Biology.—Eggs in soil. Nymphs and imago on plants in seed capsules. Hibernation as imago in colder parts of the plains only. Imago lives through periods of scarcity till food-supply enables it to reproduce.

Food Plants.—Cotton, bhinda, hollyhock, silk cotton (*Bombax hibiscus*). Usually oily seeds of *Malvaceæ*.

Status.—Major pest, rarely seriously destructive in any one place but causing a great aggregate loss. General and regular.

CAPSIDÆ.

222. CALOCORIS AUGUSTATUS.—Leth., Indian Museum Notes, III, 2, p. 9 (Fig. l, i).
Dist., F. Ind. Rhynch. II, p. 452.
Indian Insect Pests, p. 236 (Fig. i).

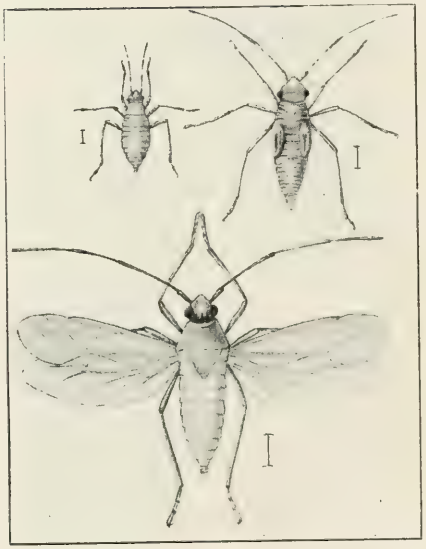


FIG. 79. CALOCORIS AUGUSTATUS.
Nymphs and imago.

Length, 6—7 mm. Dull green.

Distribution.—South Arcot, Coimbatore.

Biology.—Nymph and imago in heads of grain. Found in June.

Food Plants.—Juar, bajra (*Pennisetum typhoideum*).

Status.—Minor pest, local and sporadic.

FULGORIDÆ.

4. Liburnia psylloides.—Leth., Dist. F. Ind. Rhynch. III, p. 484.
(*Delphax psylloides.*) Indian Museum Notes, III, p. 105 (Figs. e, n, i).
(*Delphax psylloides.*) Indian Insect Pests, p. 137 (Fgs. e, n, i).

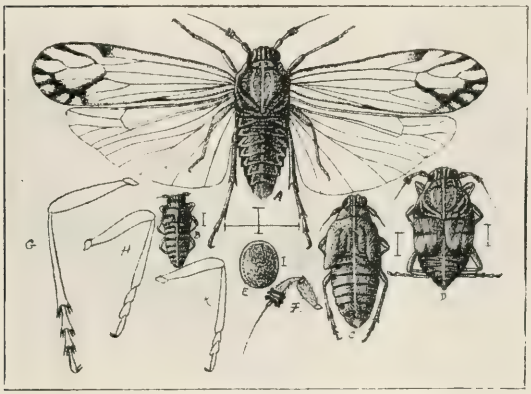


Fig. 81. Liburnia psylloides.
A. Imago. B.C.D. Nymphs. E. Egg. F. Antenna. G. H. K. legs.

Length, 5 mm. Dull brown, the wings clouded near the apex on the veins.

Distribution.—Described from Ceylon; Surat, Poona, Pusa, Nagpur. Probably general in the plains.

Biology.—Eggs in tissues of plant. Nymphs and imago on plant, gregarious. Hibernation uncertain, found in hot weather and rains.

Food Plants.—Maize and juar.

Status.—Minor pest of young crops.

FULGORIDÆ—(*contd.*)

147. DICTYOPHARA PALLIDA.—Don. Ins. of Ind., 1st Edit., (Fig. i).
Dist. F. Ind. Rhynch. III, p. 243.
Indian Mus. Notes, V (Figs. e, n, i).
Indian Insect Pests, p. 134 (Figs. e, n, i).

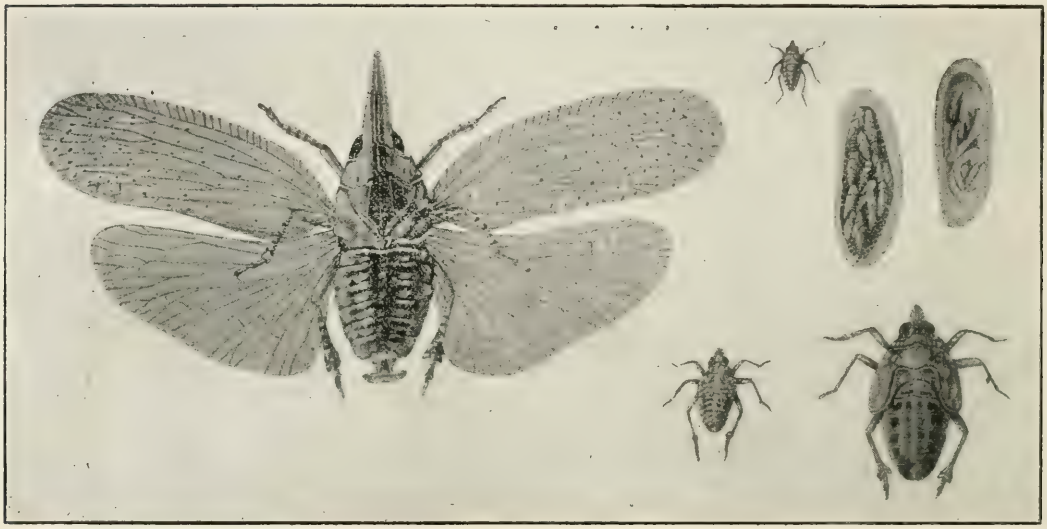


FIG. 80. DICTYOPHARA PALLIDA.
Eggs, nymphs, imago, denuded of waxy covering.

Length, 8 mm. Dull orange, the wings with many fine black spots, clouded with black towards the apex.

Distribution.—Arcot, Cawnpore, Tirhoot, Lahore.

Biology.—Eggs in clusters on leaves, nymphs and imagos active on leaf. Throughout the year, no hibernation in the plains.

Food Plants.—Sugarcane, grasses, oats, maize, juar.

Status.—Minor pest, causing black blight.

APHIDES.

162. Aphis brassicæ.—Linn. Syst. Nat., I, II, p. 734.
Indian Insect Pests, p. 239.

Wingless female.—Green, the siphons, tarsi, end of rostrum, apical half of antennæ dark. Siphons long. Cauda long, light coloured.

Winged female.—Head and thorax dark. Abdomen green, black spots at the side. Ends of femora and tibiæ dark. Antennæ dark. Siphons and cauda green.

Distribution.—General in India. Europe and Australia.

Biology.—Throughout the year if food is available. Winged and wingless parthenogenetic generations.

Food Plants.—Sarson, toria and other cruciferous crops and vegetables.

Status.—Major pest, causing great losses to early cruciferous crops.

APHIDES—(*contd.*)

8. APHIS GOSSYPII.—Glov. Rept., U. S. Dept. Agric., 1876, pp. 36, 62.
Pergande. Insect Life, VII, 314.
Agri. Journ. I., p. 50 (Fig. n, i).
Indian Insect Pests, p. 110 (Fig. n, i).

Apterous female.—1·6 mm. Yellow to green. Antennæ pale, apex dark. Siphons black, clothed in a light secretion.

Winged female.—Expanse 5 mm. Dark green, head, antennæ prothorax, spots on abdomen, siphons black.

Distribution.—America, Egypt; India, general in the plains.

Biology.—Throughout the year on cotton when available. Winged and wingless viviparous females only known in India.

Food Plants.—Cotton; elsewhere it has numerous food-plants, and probably has in India, but has not been definitely identified on any but this plant.

Status.—General major pest, of regular occurrence.

APHIDES—(*contd.*)

83. APHIS CARDUI.—L. (var.). Syst. Nat., II, pp. 735, 17. Indian Insect Pests, pp. 150-239.

Winged female.—Shiny black, legs white with ends of tibia black. Antennæ white, basal joint black. Siphons and cauda black.

Wingless female.—Shiny black, legs white, ends of joints dark. Antennæ white, base and apex dark. Siphons and cauda black.

Distribution.—Europe, Behar, Dekhan, Gujarat (probably general in India).

Biology.—Throughout the year. The winged and wingless viviparous parthenogenetic females compose the colonies.

Food Plants.—Tur, indigo, guar, sissoo.

Status.—Minor pest. Sporadically injurious.

APHIDES—(*concld.*)

163. SIPHONOPHORA GRANARIA.—Kby. Trans. Linn. Soc., IV, p. 238 (1798).
Indian Insect Pests, p. 124.

Apterous female.—Green, siphons long and dark, tarsi and antennæ dark. Cauda long, yellow.

Winged viviparous female.—Thorax brown, abdomen green; siphons, antennæ, apices of femora and tibiæ dark.

Distribution.—Europe, Plains of Behar, United Provinces, Central Provinces, Bombay Presidency, Punjab.

Biology.—Active in cold weather. From March to November in doab grass and other thick growing grasses.

Food Plants.—Wheat, barley; oats (rarely).

Status.—Serious pest, of regular occurrence in varying amount.

ALEURODIDÆ.

ALEURODES BARODENSIS.—Mask. Trans. N. Z. Ins., 1895.
Indian Mus. Notes, III-V (Figs. e, n).
Indian Insect Pests, p. 135 (Figs. e, n).

Nymph dark brown, elliptical, margin crenulate, with a broad white fringe.

Distribution.—Baroda, Samalkot, Behar; probably general.

Biology.—Eggs on leaf. Larva, pupa fixed to leaf. Young form active. Hibernation doubtful.

Food Plant.—Cane.

Status.—Major pest of irregular occurrence.

COCCIDÆ.

LECANIUM VIRIDE.—Gre. Ent. Mo. Mag. 1889, p. 248.
Green, Cocc. of Ceylon, III, p. 189.
Indian Museum Notes, I, p. 113.
Indian Insect Pests, p. 244.

Female.—Oval, flattened, green, with a sinuous dorsal black line.

Distribution.—Pulney hills, Nilgiris and Wainaad, South India, Ceylon, West Indies, West Africa, Brazil, Mauritius.

Biology.—Ovo-viviparous females only occur; found throughout the year so long as food is obtainable.

Food Plant.—Coffee. Elsewhere omnivorous.

Status.—A serious pest of coffee.

COCCIDÆ—(*contd.*)

LECANIUM HEMISPHÆRICUM.—Targ. Studi. Sulle. Cocc., p. 27.
Green, Cocc. of Ceylon, III, p. 232 (Fig. n, i).
Indian Museum Notes, I, p. 113.
Indian Insect Pests, p 244.

Female.—Rounded, not flattened, shiny brown, very finely punctate.

Distribution.—Ceylon, S. India, West Indies, United States. Universal in tropics. In temperate regions in greenhouses.

Biology.—Females occur alone, as a rule. Eggs dormant from October to April in hills.

Food Plants.—Coffee. Many cultivated plants.

Coccidæ—(*concld.*)

Dactylopius citri.—Risso. Esai, Hist. Nat. des Oranges.
Indian Museum Notes, V, p. 102.
Indian Insect Pests, p. 245.

Female.—Pink, covered in white mealy wax. No long tail filaments, evenly disposed, short lateral waxy filaments.

Distribution.—Europe, Sandwich Islands, Mauritius, Brazil, West Indies, United States. In India, widely spread.

Biology.—Females below ground on roots, on plant, in ant-shelters. Active throughout the year.

Food Plants.—Coffee, croton.

Status.—Major pest to coffee, of infrequent occurrence.

LIST OF PLANTS.

	Pages.
Abutilon indicum	183, 184, 236.
Akh (*Calotropis*)	227.
Amaranthus	173, 208.
Ambadi (*Hibiscus cannabinus*) ...	173, 181, 183, 184.
Bael (*Aegle marmelos*)	152.
Bajra (*Pennisetum typhoideum*) ...	160, 165, 195, 210, 238.
Bamboo	141.
Barley (*Hordeum vulgare*)	169, 244.
Beet root (*Beta maritima*)	208.
Ber (*Zizyphus jujuba*)	152.
Bhinda (*Hibiscus esculentus*) ...	118, 142, 173, 178, 179, 183, 184, 212, 237, 238.
Brinjal (*Solanum melongena*) ...	132, 133, 180, 203, 214.
Cabbage (*Brassica oleracea*) ...	169, 171, 173, 190, 215, 225.
Cane (*Saccharum officinarum*) ...	78, 80, 120, 126, 140, 153, 171, 176, 195, 197, 199—202, 210.
Carrot (*Daucus carota*)	165.
Castor (*Ricinus communis*) ...	118, 157, 165, 171, 211, 230.
Cauliflower (*Brassica oleracea*) ...	171, 193.
Celery (*Apium graveolens*)	171, 193.
China (*Penicum miliaceum*) ...	142.
Citrus plants	152.
Coleus	171.
Cocoa (*Theobroma cacao*)	211.
Cocoanut (*Cocos nucifera*)	130, 146.
Coffee (*Coffea arabica*)	141, 156, 167, 233, 246—248.
Cotton (*Gossypium* spp.)	118, 123, 124, 134, 142, 143, 160, 165, 168, 173, 177, 178, 181, 183, 184, 205, 212, 223, 236, 237, 242.
Croton	288.

	Pages.
Cruciferæ	127, 151, 169, 190, 192, 215, 225, 232, 241.
Crotalaria, wild	158.
Cucurbitaceæ	132, 133, 137, 138, 194, 213, 220, 227, 228.
Datura stramonium	165.
Desmodium	186.
Dudhia (*Euphorbia pilulifera*) ...	185.
Fruit Trees	124, 125.
Ganja (*Cannabis sativa*)	165.
Glycosmis pentaphylla	152.
Gram (*Cicer arietinum*)	143, 165, 169, 174, 192.
Grasses	119, 120, 121, 139, 147, 168, 172, 198, 199, 200, 209, 235, 240.
Groundnut (*Arachis hypogea*) ...	118, 126, 160, 161, 169, 171, 226.
Guar (*Cyamopsis psoralioides*) ...	243.
Guava (*Psidium guyava*)	150.
Halim (*Lepidium sativum*)	215.
Hibiscus, garden	237.
Hollyhock	212, 237.
Hops (*Humulus lupulus*)	169.
Indigo (*Indigofera* spp.)	118, 123, 124, 142, 163, 165, 167, 168, 171, 173, 186, 243.
Juari (*Andropogon sorghum*) ...	126, 131, 135, 143, 147, 160, 162, 175, 176, 187, 195, 210, 230, 231, 238, 239, 240.
Jute (*Corchorus* spp.)	160, 173, 182.
Kangni (*Setaria italica*)	129.
Khanghi (*Abutilon indicum*) ...	183, 184, 236.
Khesari (*Lathyrus sativus*)	204.
Khorasani (*Guizotia abyssinica*) ...	126.
Kulthi (*Dolichos biflorus*)	154, 219, 220.
Kutki (*Panicum* spp.)	131, 135.
Leguminosæ	137, 216, 234.
Lentil (*Ervum lens*)	173.
Linseed (*Linum usitatissimum*) ...	160, 169, 193.
Lobia (*Vigna catjang*)	149, 154.
Loquat (*Eriobotrya japonica*) ...	150.
Lucerne (*Medicago sativa*)	117, 123, 165, 169, 171, 173, 192.

	Pages.
Maize (*Zea mais*)	135, 142, 143, 160, 165, 171, 172, 173, 174, 175, 176, 177, 187, 195, 208, 210, 231, 239, 240.
Malachra capitata	165, 181.
Malvaceæ	137, 183, 184, 236, 237.
Mangel Wurzel (*Beta maritima*) ...	143, 160, 165, 169, 173.
Mango (*Mangifera indica*)... ...	126, 145, 227.
Marua (*Eleusine coracana*) ...	171, 172, 191.
Melon (*Cucumis* spp.)	229.
Millets	120, 135, 136, 231, 235.
Moonj Grass (*Saccharum ciliare*) ...	199.
Moth (*Phaseolus aconitifolius*) ...	126, 191, 216.
Mulberry (*Morus* spp.)	171.
Mung (*Phaseolus mungo*)	149, 216.
Oats (*Avena sativa*)	126, 165, 169, 240, 244.
Onion (*Allium cepa*)	165.
Opium (*Papaver somniferum*) ...	118, 143, 165, 169, 170.
Palms	121, 130, 146.
Pea (*Pisum* spp.)	160, 165, 169, 173, 183, 192, 204.
Phaseolus trilobus	149.
Pomegranate (*Punica granatum*) ...	150.
Popat (*Dolichos lab-lab*)	154, 219, 243.
Potato (*Solanum tuberosum*) ...	132, 169, 171, 230.
Randia dumetorum	150.
Rape (*Brassica napus*)	225, 232, 241.
Rice (*Oryza sativa*)	120, 129, 135, 136, 139, 140, 147, 148, 153, 160, 162, 171, 172, 173, 175, 176, 187, 188, 197, 198, 199, 206, 207, 209, 230, 235.
Safflower (*Carthamus tinctorius*) ...	126, 173, 191.
Sama (*Panicum frumentaceum*) ...	143, 176, 235.
Sandal (*Santalum album*) ...	156.
Sann (*Crotalaria juncea*)	158, 159, 160, 164, 191, 204, 222.
Saidi bean	204.
Silk Cotton (*Bombax malabaricum*) ...	237.
Solanaceæ	132.
Soy beans (*Glycine soya*)	160, 217.
Strawberry (*Fragaria*)	126.
Sunflower (*Helianthus annuus*) ...	126, 143, 155, 160, 162, 165, 211.

	Pages.
Sweet Potato (*Ipomœa batatas*) ...	144, 155, 162, 171.
Til (*Sesamum indicum*)	154, 160, 162, 218.
Tipari (*Physalis peruviana*) ...	166.
Tobacco (*Nicotiana tabacum*) ...	118, 119, 123, 124, 125, 165, 166, 168, 169, 170, 171, 224.
Tomato (*Lycopersicum esculentum*) ...	165.
Tur (*Cajanus indicus*)	142, 149, 165, 171, 216, 219, 220, 221, 234, 243.
Urid (*Phaseolus radiatus*)	160, 171, 186, 191.
Val (*Dolichos lablab*)	154, 219.
Wheat (*Triticum sativum*)	126, 143, 169, 171, 176, 244.

INTRODUCTION.

A word of explanation is desirable as to the joint responsibility for this Memoir. Mr. C. C. Ghosh is in charge of the Pusa insectary and made the detailed study of the life of the insect which occupies pages 260—272. His account is given in full with only small additions. The remainder of the Memoir is my own, with the additions noted under their authors' names.

PUSA,
Dated February, 1907.

H. MAXWELL-LEFROY,
Imperial Entomologist.

THE INDIAN SURFACE CATERPILLARS OF THE GENUS AGROTIS.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist;

AND

C. C. GHOSH, B.A.,

Assistant to the Imperial Entomologist.

DESCRIPTION.

The genus *Agrotis* as it stands in Hampson's Fauna of India, Moths, Volume II, has been revised in the same author's catalogue of Lepidoptera Phalænæ, now in course of publication, and has been scattered among several genera. Of the recorded Indian species, four only are widespread in the plains of India, and have some economic importance. *Agrotis ypsilon*, Rott, is the commonest Surface Caterpillar (cutworm) of India; *Agrotis flammatra*, Schiff, is occasionally an extraordinarily abundant insect. *Euxoa* (Agrotis) *segetis*, Schiff, and *E. spinifera*, Hubn., are also common, and since their life-history seems to be very close to that of *Agrotis*, may be included in this paper. The description of each species as it occurs in Hampson's Catalogue of Lepidoptera Phalænæ is reprinted here for reference; the species are also figured in Plate I.

Euxoa spinifera—*Hubn.*

Male.—Head and thorax grey-white mixed with pale brown and a few black scales; palpi blackish at sides except at extremity; tegulæ with dark medial line; tarsi black, ringed with white; abdomen white, dorsally tinged with ochreous. Fore-

wing pale ochreous with a violaceous tinge and slight fuscous suffusion, especially on costal area; the veins slightly streaked with fuscous; an indistinct double subbasal line from costa to submedian fold; the antemedial line represented by oblique double striæ from costa and a slightly curved line from median nervure to vein 1; the claviform very elongate lanceolate, strongly defined by black and filled in by dark brown; the orbicular and reniform with fuscous centres and ochreous annuli defined by black, the former elliptical and with its outer edge produced to a point, often open above, the latter often angled inwards on median nervure, a black fascia between them in cell and slight streaks from outer edge of reniform; the postmedial line hardly traceable, dentate, bent outwards below costa, excurved to vein 4, then incurved; the subterminal line pale, dentate to termen on veins 7, 4, 3, with dentate black marks on its inner side at middle, and the area beyond it blackish except towards apex and tornus; a terminal series of black points. Hindwing semihyaline white, the costal area suffused with ochreous, a fine terminal line on costal half.

Female.—Usually darker; hindwing with the veins, costal and terminal areas tinged with fuscous.

Expanse 26—40 mm.

Euxoa segetis—*Schiff.*

Male.—Head and thorax pale brownish ochreous slightly irrorated with black, palpi brown at sides, antennæ brown, tarsi banded with fuscous; abdomen whitish, tinged with brown. Forewing pale brownish ochreous striated with brown, a double fuscous subbasal line from costa to submedian fold interrupted at cell; a double waved antemedial line, the outer stronger; claviform elongate, usually small, outlined with black; orbicular and reniform defined by black and with brownish centres, the former small or large, round or somewhat elliptical, the latter usually well developed; an oblique medial shade from lower angle of cell to inner margin; the postmedial line dentate, bent outwards below costa, excurved to vein 4, then oblique; the subterminal

line indistinct, pale, defined by brown on inner side, angled outwards at vein 7, and excurved at middle ; a terminal series of black points. Hindwing semihyaline white, the veins, costa, inner margin, and termen tinged with brown ; the underside with the costal area irrorated with brown and crossed by a postmedial striga. Specimens are often tinged with reddish brown or fuscous.

Female.—Nearly always darker and suffused with reddish brown or fuscous ; forewings sometimes fuscous black, the markings obscured.

Expanse 30—46 mm.

AGROTIS FLAMMATRA—*Schiff.*

Head and thorax grey-brown, tinged with purplish red ; palpi dark brown at sides except at tips ; tegulæ with semicircular black brown patch ; tarsi with pale rings to the joints ; abdomen pale grey-brown. Forewing grey-brown tinged with purplish red ; the costal area usually pale to middle or postmedial line ; the subbasal line represented by slight double striæ from costa ; a black streak in base of submedian fold, expanding beyond the subbasal line ; the antemedial line double, waved, almost obsolete on costal area ; claviform with its extremity slightly defined by black ; orbicular and reniform brownish-grey, the former rounded, open above, defined by black below, the latter defined by black on inner side, or with the cell black before the orbicular and sometimes also between the stigmata ; the postmedial line minutely dentate, slightly defined by ochreous on outer side, bent outwards below costa, excurved to vein 4, then incurved and slightly angled outwards on vein 1 ; the subterminal line greyish, often defined by slight dentate black marks on inner side, angled outwards at vein 7, and slightly dentate at veins 4 and 3 ; traces of a terminal series of black points and a fine ochreous line at the base of cilia. Hindwing ochreous whitish suffused with pale brown ; the cilia white, with a brown line at base ; the underside whitish, the costal area irrorated with brown, a slight discoidal lunule and sinuous postmedial line.

Expanse 40—60 mm.

AGROTIS YPSILON—*Rott.*

Head and thorax red-brown, the latter suffused with fuscous; frons with blackish bar above; back of head with two black spots; tegulæ with brown and black medial band; pectus whitish; tibiæ and tarsi ochreous white and black; abdomen grey-brown. Forewing ochreous irrorated with brown; the costal area suffused with fuscous brown, and often the whole wing to the postmedial line; a double, waved, subbasal line from costa to the submedian fold, a double, waved, antemedial line, dentate inwards on median nervure and vein 1 and outwards above inner margin; claviform moderate or small, defined by black; orbicular and reniform defined by black and fuscous centres, the former small, elliptical, or with its outer edge produced to a point, the latter with wedge-shaped black spot from its outer edge; an indistinct dentate medial line; a double minutely dentate postmedial line produced to points on the veins, bent outwards below costa, excurved to vein 4, then incurved; a subterminal series of pale and black dentate marks, those above veins 4, 5, with the black on their inner side stronger and some fuscous suffusion on the outer; the veins towards termen with dark streaks; a terminal series of points. Hindwing semihyaline white, the veins, costal and inner areas, the termen tinged with brown strongly, strongly in female and in the New Zealand form.

Expanse 40—50 mm.

2. EUXOA SPINIFERA—*Hubn.*

A list of synonyms will be found in Hampson's Catalogue of Lepidoptera Phalænæ, Vol. IV, p. 177. The original description is given in Hubner's Sammlung Europæischer Schmetterlinger, Noctuidæ, Fig. 389 (1827). The species figures as *Agrotis biconica*, Koll, in the Fauna of India, and also in Indian Museum Notes, and this is practically the only synonym necessary to the Indian student. Hampson records it from a long list of localities covering South Europe, Egypt, the East and South portions of Africa, Syria, Persia, Kashmir, the Himalayas, the plains of

India, Ceylon, Burma. There is a single reference to it in Indian Museum Notes, Vol. IV, p. 195, where it is stated to have been reared from a batch of caterpillars which were received in March 1897, from Messrs. Finlay, Muir & Co. as attacking indigo plants in Tirhut. There appear to be no further references to its destructiveness in India, and it has only once been definitely reported as a pest since this last reference. Specimens were received from the Deputy Commissioner of Gujrat, Punjab, with a report that the caterpillars were attacking young cotton plants. A single specimen of the moth was reared from a batch of Surface Caterpillars found on gram in Pusa in November 1906, the remainder being *Agrotis ypsilon.*

The distribution recorded for the species by Hampson and by the Indian Museum Collections shows it not to be a common species in the plains of India, but rather a hill species found but rarely outside hill localities. Actually it is apparently one of those insects which is normally an ordinary member of the insect fauna, known only to insect collectors, but which occasionally becomes abundant enough to attack crops sufficiently to become noticeable. The larvæ received from Gujrat were similar to those of *Agrotis ypsilon* described below, but more brown in colour. They were sent in May, and moths emerged at varying dates during June. The species was also reared from caterpillars found at the roots of plants, and it is probable that the larva could be readily found widely in India if searched for in weedy land or land on which low growing plants were growing.

3. Euxoa segetis—*Schiff.*

The description is (Wien. Verz., pp. 81, 252, 776) under the genus *Noctua.* Hampson in Fauna of India, Moths, Vol. II, p. 181, refers to it under *Agrotis* and in Catalogue of Phalænæ, Vol. IV, p. 167, gives a list of synonyms, none of which are necessary for the literature of this species in India. The distribution is wide, covering Europe, East and South Africa, Japan, China, Afghanistan, Kashmir, the Himalayas and hill localities

in India. There are two references to it in Indian Museum Notes. In Vol. II, p. 6, the moth is recorded as one of two reared from caterpillars which ringed young coffee plants in Mysore in January ; it was stated that over 110,000 had been destroyed by handpicking. The second reference is in Vol. V, p. 145, covering a reference in Vol. IV, p. 194 ; in this case, caterpillars had been sent in from Tirhut as destructive to indigo in March 1897 ; in the same year, another Behar planter reported "caterpillar," and in 1901 Mr. L. de Nicéville visited Behar to investigate "caterpillar" ; it is now certain that the "caterpillar" referred to was not *Euxoa segetis* but *Caradrina exigua*, and it is to this latter insect that the remaining information in Vol. V of Indian Museum Notes refers. We have then no information beyond the isolated fact of the occurrence of this insect in Behar feeding on young indigo plants. Amongst the many injurious insects bred in the Central Provinces, this species occurred once on cabbage at Nagpur (Ratiram Khamparia). The insect has not been reported as a pest since 1901, but is very likely to be found as a surface caterpillar in any hill locality. Meyrick (Handbook of Lepidoptera) states that the larva occurs in England from July to April, the imago from June to August ; the larva feeds on the roots of a variety of plants. For the Indian student the species may be classed as one which may possibly be found at any time, but is unlikely to occur as a pest in the cultivated plains. It will be distinguishable only as a moth, and will be confused with *Caradrina* unless carefully examined.

4. Agrotis Flammatra—*Schiff.*

This species was described in 1776 (Wien. Verz., p. 80), and by Hampson on p. 189 of the second volume of the Fauna of India, Moths, and on p. 393 of the fourth volume of the Catalogue of Lepidoptera Phalænæ. It is referred to once in Indian Museum Notes under the generic name *Ochropleura*. Its distribution covers Europe, Syria, Persia, W. Siberia, Kashmir, the Himalayas, and some places in the plains of India. The single reference to it in Indian Museum Notes states that it was injuring

opium plants (with *Agrotis ypsilon*) in Oudh in March 1890. In March 1905, the moths were extremely abundant at Pusa (Bengal), literally thousands coming out in the dusk to fly about the trees and also coming to lights. For a few days this extraordinary phenomenon lasted, the moths hiding by day in corners and shady places, coming out in the evening and crowding in the trees where they fed on the nectar of the flowers of sissoo (*Dalbergia sissu*). If these moths had laid eggs in the crops, not a plant would have escaped, but no injury was done to the crops nor have the moths been abundant since that time. They were found in small numbers in March 1906 and at no other time. Larvæ have been searched for and found commonly at the roots of grasses and at the roots of tobacco, in neither case being destructive. Hampson states the larva to be uniform green with pale spiracular stripes; Pusa larvæ were dull green like a rather green *Agrotis ypsilon* larva. This species has not been reared as a pest, nor has it been sent in during the past few years; it may, however, be regarded as a potential pest, which may at any time occur seriously. A curious feature of the insect is its occurrence as an imago in thatched roofs; apparently it hibernates there as an imago and is found abundantly during the cold weather, emerging in March.

5. Agrotis ypsilon—*Rott.*

A full description, with references to the original description (Naturf. IX, p. 141, 1776), and synonyms, is given by Hampson on p. 368 of Vol. IV of Catalogue of Lepidoptera Phalænæ. The most important synonym is *Agrotis suffusa* of Schiff and Fabr., under which name it is referred to in Indian Museum Notes and other Indian publications, which got their information from this source. The distribution is almost universal; North and South America, Europe, N. Africa, Syria, Japan, China, Tibet, Kashmir, the Himalayas, Ceylon, Java, Australia, New Zealand and Hawaii are included. In India proper, the distribution is, so far as is known, peculiar; the species is recorded from localities in the Himalayas, from localities in Behar and Oudh, and from

districts in Northern Bengal and Assam—always from localities near the Himalayas ; no specimens seem to have been reared or collected in Madras, the Central Provinces, Central India, Bombay or the Western Punjab. Whether this distribution is due to the nature of the soil being suitable only in certain tracts, or to the climate, or to the insect not having spread further, cannot be ascertained. It may not even be limited to the areas mentioned, but must at least be far commoner there than elsewhere.

6. Life History.

The life cycle of the Greasy Surface Caterpillar or Cutworm (*A. ypsilon*) as illustrated by two specially noticed, is shown below :—

Eggs laid.	Eggs hatched.	Larva pupated.	Moths emerged.
28th January.	6th February.	11th March.	29th March.
7th March.	12th March.	10th April.	22nd April.
7th ,,	12th ,,	11th ,,	22nd ,,

The period varies a great deal in summer and winter ; in summer the life cycle may be completed in about half the time taken in winter. As will be seen later on, the egg stage varies from about two days in summer to about seven or eight days in winter ; the larval stage may vary from about 25 days to more than 35 days ; and the pupal stage varies from about 10 to 28 days.

Egg.—The egg is domeshaped, about $\frac{1}{2}$ mm. wide from side to side, and creamy white in colour. There is a small circular depression at the top and from its periphery ridges run down the sides to the basal circumference. During the day the moths remain hiding in dark corners and cracks. They are also seen to sit close to the ground near the stems of plants. Their legs and wings are held close to the body, and on being touched they sometimes feign death. When disturbed they shoot out and try to secure another dark corner or hiding place by a sort of jerky motion which is not flying. But at night when they alight or walk upon the ground, the wings do not remain closely applied to the body but in a horizontal position, and the body is as much above the ground as the legs can raise it. They come out of their

hiding places as soon as it is dusk and fly about until complete darkness sets in. Oviposition commences some time after this, and continues up to a late hour. The eggs laid by a moth up to 8 p.m. in a winter night were noticed; but the next morning nearly twice as many eggs more were found to have been laid during the night.

It has been found by supplying shoots of plants which the insects were damaging at the time, that the moths prefer to lay eggs on gram, poppy and tobacco. Eggs are laid generally on leaves and parts of stems which are near the ground. The abdomen is curved downwards and so bent that the egg is deposited on the sides of leaves or stems, almost opposite to that on which the moth takes its position. It is due to this fact that the majority of eggs come to be laid on the underside of leaves and stems. From one to about thirty eggs may be laid at one place, and when laid together, they are juxtaposed and touch one another. During the time oviposition continues, the moth may be seen to walk, with its wings in a horizontal position, from place to place over the ground. In the insectary, at intervals, it came to drink food. The food supplied was sugared water to which was added a drop of vinegar.

Three or four moths used to be put together in a cage and separated on the day after eggs had been laid for the first time. In this way the oviposition record of three separate moths has been found out. The following table shows the number of eggs a moth can lay, for how many days it can continue to lay eggs and how many eggs it can lay in all. The first two moths were fed only twice and the third moth was fed regularly every day.

	Oviposition commenced.	Eggs on 1st day.	Eggs on 2nd day.	Eggs on 3rd day.	Eggs on 4th day.	Eggs on 5th day.	Eggs on 6th day.	Eggs on 7th day.	Eggs on 8th day.	Eggs on 9th day.	Eggs on 10th day.	Eggs on 11th day.	Total.
1	28th January ...	19	38	79	19	67	..	..	...	...	...	...	222
2	,, ,, ...	9	10	9	6	59	44	62	...	...	...	...	199
3	15th March ...	25	...	14	39	40	59	25	17	37	53	35	344

From the above statement it will be seen that a moth can lay up to 79 eggs in a single day, that egg-laying may continue for eleven days, and that a single moth can lay up to 344 eggs. But there is reason to believe that a moth which moves about freely and which in its larval stage has fed freely, can lay a larger number of eggs. No egg was laid on the day before death. The eggs of the first two moths did not hatch owing to being placed in unfavourable conditions, but all of the 344 eggs of the third moth hatched.

The colour of the egg undergoes some change after a period varying from about 12 hours in summer to about 3 days in winter. The depression at the top becomes brown and a broad brown belt appears on the side halfway from the top. The general colour is dull. Some time before hatching a black spot appears at the top marking the position of the head within. The larva eats out a hole in the shell and after it comes out through this hole, it feeds first on the shell. The shell may be wholly eaten or a portion of it left.

Below is shown the duration of the egg-stage, which varies from about 2 days in summer to about 8 or 9 days in winter.

Eggs laid.	Eggs hatched.	Duration.
28th January (night) ...	5th February (night) ...	About 8 days.
5th March (night) ...	12th March (morning) ...	,, 6½ ,,
7th ,, ,, ...	,, ,, (night) ...	,, 5 ,,
8th ,, ,, ...	13th ,, (noon) ...	,, 4½ ,,
17th ,, ,, ...	23rd ,, ,, ...	,, 5½ ,,
19th ,, ,, ...	Some on 21st March (noon) ..	,, 1½ to 5 days.
	Rest on 24th March (night) ...	
23rd ,, ,, ...	27th March (night) ...	,, 4 days.
24th ,, ,, ...	Some on 26th March (night) ...	,, 2 to 3 days.
	Rest on 27th March ,, ...	
25th ,, ,, ...	Some on 27th March (morning)	,, 1½ days.

Removal from the plant has no effect upon the eggs. Some of the eggs laid on the 5th March were kept in a glass pot

covered with a ground-glass covering. They hatched almost at the same time as those left on the plant.

The effect of the sun on the eggs is not perceptible. Eggs laid on the 8th March, and kept always exposed to the sun from the beginning, hatched on the 13th; while those laid on the 7th and kept always in the shade, hatched on the 12th, *i.e.*, after the same number of days.

The effect of submergence in water also is not appreciable, so long as the leaves or stems on which the eggs are deposited, do not rot. Its effect may be to prolong the egg-stage for some time. A branch of the plant, the eggs on which were kept exposed to the sun, was so managed from the beginning that the eggs on it remained part of the day under water and the rest of it in moist earth. They hatched about 30 hours after those exposed to the sun had hatched. Some of the eggs laid on the 7th March were kept under water in a pot for about three hours, and they hatched at the same time as those left on the plant. Again, some eggs laid on the 25th March were kept under water in a pot for about 16 hours; these did not hatch, but some of the eggs showed no external change. The rotting of the leaves on which they were deposited had probably something to do with their failure to hatch.

Larva.—The larva just hatched is about $1\frac{1}{2}$ mm. long, its head is shiny black, the prothorax bears a small black shield, the body is cylindrical, the general colour is slightly yellowish gray. The first two pairs of prolegs are not well developed; therefore the larva has a gait somewhat like that of a semilooper, *i.e.*, in locomotion a hump appears near the middle of the body. The young larvæ, like the full-grown ones, have the habit of coiling up at the slightest touch or breath of wind, so that when they are engaged, after emergence, in the eating of the eggshells, the slightest shaking of the plant or the softest breeze causes all of them to fall to the ground. They do not or cannot climb the plants to get at the leaves for food. Their food habit is remarkable in this way that they can eat and live upon even the old yellow leaves as long as they are soft. The young larvæ, therefore,

feed upon fallen leaves and leaves of those branches which happen to lie on the ground. They do not make holes in the earth but generally live hidden under the leaves which they eat. They do not show the cannibalistic habit of the advanced larvæ.

The newly hatched larva is slightly yellowish gray in colour. After about 24 hours, the thorax becomes light green and minute black points appear scattered over the body, distinctly visible through the lens. After about one day more a portion behind the head becomes whitish, behind this a portion becomes light green, and the rest of the body is yellowish. Again, there is a change, and the colour becomes uniform pale orange yellow. Then after the first moult the colour is yellowish with a greenish tinge, and a thin median line appears on the dorsum. After the second moult the characteristic markings of the full-grown larva are perceptible ; the general colour becomes dark and in successive moults it becomes darker.

In the insectary the caterpillars have been fed with leaves of poppy, gram, lucerne, celery, clover, mangold, tobacco, sunflower, cotton, bean, cabbage, radish, mustard, brinjal, potato, plantain, and several weeds including grass. They can live upon all these kinds of leaf, and thus never run the risk of dying of starvation. Among the above plants, they prefer poppy to all the rest, and next to that, gram, tobacco, brinjal, mustard and radish. Poppy seems to be a very nourishing food for them and develops them quickly. Some of the larvæ which hatched on the 12th March were exclusively fed with poppy, and the others with gram, and only occasionally with celery and lucerne. On the 31st, those feeding on poppy measured from about 34 to 42 mm., while those on gram measured from about 20 to 28 mm. This difference in growth, due to poppy and gram, was also noticed in the case of the first two larvæ, which were being specially watched for moults. For some time after hatching both of them were fed with gram, but afterwards poppy was given to the first, and gram was continued for the second. At the end, however, all are seen to be equally developed, but those which grow quicker pupate earlier.

Four larvæ were specially watched to see how many moults they cast. In the following statement will be found the number of moults, the period of each instar and growth in successive instars : —

	Hatched.	1st moult and length after moult.	2nd moult and length after moult.	3rd moult and length after moult.	4th moult and length after moult.	5th moult and length after moult.	6th moult and length after moult.	7th moult.
1	12th March	18th Mar. 4 mm.	22nd Mar. 6 mm.	25th Mar. 12 mm.	28th Mar. 19 mm.	2nd Apr. 38 mm.	10th Apr. (pupated.)	
2	,, ,,	18th Mar. 4 mm.	22nd Mar. 6 mm.	24th Mar. 8 mm.	27th Mar. 15 mm.	29th Mar. 21 mm.	4th Apr. 35 mm.	11th April. (pupated.)
3	6th February	13th Feb.	18th Feb.	22nd Feb.	27th Feb.	3rd Mar.	11th Mar. (pupated.)	
4	,, ,,	,, ,,	,, ,,	23rd ,,	,, ,,	,, ,,	11th Mar. (pupated.)	

The full-grown larvæ attain a length of about 42 mm. to 45 mm. at the time when they begin to rest before pupation. Out of the 4 larvæ watched : 3 pupated at the 6th and 1 at the 7th moult. Before each moult the larva rests for some time and, as will be seen later on, takes no food. While it rests, the prothorax is a little prolonged, forming a sort of a neck behind the head. In all the moults except the last one at which the larva turns into the chrysalis, the moult of the head is cast separately by rubbing the head against any surface. When the skin is being shed, the larva does not appear to be very uncomfortable, as it can move about while the skin slips slowly towards the hind end. Just after the moult the head is soft and somewhat creamy white ; the body also is not so dark as is seen normally. It is strange that eating the cast skin is not a general habit among the cutworm larvæ, which are so much addicted to cannibalism ; cast-off skins are rarely eaten. The full-grown larva is a dark-coloured, sometimes dark-brown, plump-bodied caterpillar and measures about 44 mm. or $1\frac{3}{4}$ inches. Its average daily growth is, therefore, about $1\frac{1}{2}$ mm. The head is shiny, slightly reddish black and compressed dorsoventrally and bears an inverted V-shaped mark. The prothorax bears a slightly

reddish black shield. On the upper part of the dorsum there is a broad longitudinal whitish space traversed by the more or less interrupted median line. The rest of the upper side of the body is dark or blackish. The ventral colour is muddy gray. The five pairs of prolegs are thick, fleshy. At rest as well as in locomotion, the ventral surface of the body always touches the ground. On being touched the larva coils in the form of a disc.

The young larvæ eat the epidermis of the leaves that are available on the ground and are generally found to live hidden under those leaves. As they grow, their habit changes. They live in cracks or holes which they make in the ground, and very seldom come out during the day, although occasionally one may be found to walk from one place to another. They are active principally at night, and fell the plants by cutting their stems either below the surface of the ground or above the ground, thus getting plenty of leaves on the ground. Cut branches are sometimes seen to be dragged into the holes, where the leaves are eaten at leisure. Cabbages are bored from below and the larvæ may be found in the bore.

The feeding habits of a larva are best illustrated by the amount of food it eats daily. Two larvæ were kept separately. A weighed quantity of green food used to be supplied to each. The next day the quantity of food left was weighed and the quantity eaten was found out. To get at a more correct result, the same quantity of the green stuff supplied as food was separately kept in a similar manner and weighed the next day at the same time in order to find out the loss in its weight by evaporation. The weights of food eaten in the following statements are calculated by taking this loss into consideration, the lost weight being in every case wholly deducted. The weights of food eaten should be taken as approximate, when the larva ate much after the 4th moult and specially in the last instar, it did not wait so long as to let the food lose as much by evaporation as is actually deducted. In the beginning also it may have eaten more or less than what is given in the statement. The weights of the larva and of the excrements are given as they were found every day.

The newly-hatched larva weighs less than ·01 grain. In the beginning it eats so little that the amount cannot be easily determined by weighing. The weights were taken after it began to eat to an appreciable extent.

First Larva.

Date.	Food eaten in grains.	Weight of larva in grains.	Excrements in grains.	Remarks.
28th January	.....		.....	Egg laid.
6th February	.....	·01	.....	Egg hatched.
13th ,,	.....	·02	.....	First moult.
18th ,,	·1	·05	·02	Weight of excrements up to date. Second moult.
19th ,,	·2	·06	·01	
20th ,,	·3	·1	·03	
21st ,,	·2	·16	·01	
22nd ,,	·2	·19	·01	Third moult.
23rd ,,	·5	·3	·03	
24th ,,	·6	·57	·08	
25th ,,	·6	·85	·12	
26th ,,	·1	·85	·02	
27th ,,	1·1	1·4	·1	Fourth moult.
28th ,,	1·6	2·66	·4	
1st March	2·5	4·1	·6	
2nd ,,	·2	3·9	·08	
3rd ,,	·7	4·65	·2	Fifth moult.
4th ,,	4·6	8·2	·8	
5th ,,	6·7	12·7	1·7	
6th ,,	8·6	16·9	3·4	
7th ,,	6·2	18·4	3·3	
8th ,,	.....	15·1	1·4	
9th ,,	.....	8·4	.....	
10th ,,	.....	8	.....	
11th ,,	.....	7·75	.....	Pupated; weight of pupa.
19th ,,	.....	7·7	.....	
29th ,,	.....	4·2	.....	Moth emerged; weight of moth.

Second Larva.

Date.	Food eaten in grains.	Weight of larva in grains.	Excrements in grains.	Remarks.
28th January	.....	.....	.....	Egg laid.
6th February	.....	·01	.....	Egg hatched.
13th ,,	.....	·02	.....	First moult.
18th ,,	·1	·05	·02	Excrements up to date. Second moult.
19th ,,	·2	·06	·01	
20th ,,	·2	·1	·02	
21st ,,	·4	·17	·03	
22nd ,,	·1	·17	·01	
23rd ,,	·3	·23	·02	Third moult.
24th ,,	·2	·46	·07	
25th ,,	·6	·93	·15	

SECOND LARVA.—(*Concld.*)

Date.	Food eaten in grains.	Weight of larva in in grains.	Excrements in grains.	REMARKS.
26th February	·0	·85	·04	
27th ,, ...	·8	1·25	·1	Fourth moult.
28th ,, ...	1·5	2·25	·26	
1st March	2·3	3·8	·7	
2nd ,, ...	·1	3·6	·1	
3rd ,,	1·1	4·35	·1	Fifth moult.
4th ,, ...	4·5	8·1	·9	
5th ,, ...	6·1	12·9	1·5	
6th ,,	7·7	17·3	3·0	
7th ,,	5·7	18·6	3·5	
8th ,, ...	·1	14·9	·2	
9th ,, ...	.....	8·2	.....	
10th ,, ...	.....	7·6	.....	
11th ,, ...	.....	7·4	.....	Pupated; weight of pupa.
12th ,, ...	.....	7·3	.....	
29th ,, ...	.....	3·6	.....	Moth emerged; weight of moth.

An examination of the two tables of weights shows that the larva eats more as it grows and simply gorges itself with food before it pupates or enters upon the period of rest. Before each moult it abstains from food for some time and its weight is seen to actually diminish in some cases. This diminution of weight is specially evident before the last moult; the weights of both the larvæ diminished from about 18 to about 8 grains in the course of 48 hours. The pupa weighs less and the moth still less.

Both of the larvæ which were weighed attained to a maximum weight of about 18·5 grains. One of them ate about 35 grains and the other about 33 grains of green gram leaves. The average weight of a larva, which has fed in favourable circumstances in the fields, has been found to be about 20 grains. The amount of food eaten by a larva of *Agrotis ypsilon* may, therefore, be taken to be approximately 35 grains. If each female moth lays about 350 eggs, the larvæ hatched out of them destroy about $1\frac{3}{4}$ pounds of green leaves. The damage actually done, however, is considerably greater as the larvæ are in the habit of cutting down the whole plants. As the cutworm larvæ live underground, they are far less liable to be destroyed by parasites than caterpillars which live on their food-plants. But their habit of killing and eating each other results in the destruction

of a large number. When there is an insufficient supply of food, small and weak ones are devoured in lots by bigger ones ; but one will kill and eat another as big as itself. Resting larvæ and pupæ in the early stage are liable to be eaten up whenever met with, because in these cases there is no resistance at all. They are seen to eat each other with relish in presence of abundant food. It is interesting to confine some larvæ in a small space and watch their behaviour after some time when they become hungry. Each takes a bite at any one it comes across and the victim to such bites is turned into food. When too much disturbed, the larva bites at its own body.

The larval stage is about one month, being a few days more in winter and several days less in hot summer. Below are shown the larval stages of three lots.

Larvæ hatched.	Larvæ pupated.	Duration in days.
6th February	11th to 14th March	33—36
12th March	8th to 11th April	27—30
21st ,, ...	17th April	27

The underground life of the cutworm larvæ suggested the idea of finding out their behaviour in water. The small larvæ, a few days old, coil up and come to the surface of the water. They remain floating for some time, and the whole lot may be carried away by a flowing current. Older and developed larvæ come out of their holes when water is poured in : and when under water they are entirely helpless and cannot avail themselves of even any rough support which may fall in their way in their struggling movements. After struggling for about 15 minutes almost all of them become paralysed and lie as if dead at the bottom. Only in a very few cases, specially among young ones, the larvæ may not be paralysed and also can get upon any support that presents itself. But generally in such cases they remain half floating. One half-grown larva kept floating for 18 hours but died. They may revive when taken out of water, after varying periods of submergence, but long periods of submergence ensure the death of many ; and although they may show signs of life after being

taken out of water, they cannot, in most cases, pupate successfully. The following is the result obtained in several cases.

Number of larvæ.	Submerged for how many hours.	Revived.	Died.
10	3 hours.	8	2
10	5 ,,	7	3
5	8 ,,	1	4
14	20 ,,	3	11

In the third case one remained floating all the time: but it died while a paralysed one revived. The above was corroborated by the following experiment without the larvæ being actually placed in water. More than one hundred larvæ hatched on a gram plant in a flower-pot. They were left in the pot and supplied with sufficient food. The pot was placed in a dish containing water which was less than one inch and sometimes half an inch deep. When the larvæ were about 15 to 20 mm. long, they tried at night to escape from the pot, and in so doing fell into the water in the dish and died in lots of 12 to 30. Only four larvæ survived, one by remaining in the pot and three by making good their escape out of the water.

Pupa.—The larva pupates underground. In the insectary many prepared chambers of earth within which they pupated. Before pupation the larva rests for one to three days. The resting period is shorter in hot and longer in cold weather. It is still longer when it bears the maggot of a Tachina fly inside its body. When resting it shortens longitudinally, the segments of the body become well marked, and the form becomes tapering, slightly towards the head but more prominently towards the hind end. Then the upper side of the head and thorax bursts longitudinally, and the soft yellowish white chrysalis comes out by a sort of wriggling movement. In the course of about 12 hours the chrysalis hardens and becomes red-brown in colour. It is about 20 mm. long and is of the Noctuid type. The abdomen is segmented, the segments telescoping into each other and thus being capable of wriggling movements which can cause a change of position. This end is pointed, and bears small

needle-like processes. The head end is obtuse. In the advanced stage of the pupa the black eyes become prominently noticeable and the wings folded on the ventral side can be marked.

The pupal stage varies from about 10 days in summer to about 30 days in winter. The following table gives the pupal stage, together with the resting period of some which were specially noticed :—

Number of larvæ.	Began resting	Pupa.	Moth emerged	Duration.	
1		4th November.	22nd November.	18 days.	
1	26th January.	29th January.	26th February.	28 ,,	
1		,, ,,	1st March.	31 ,,	
2		9th February.	11th ,,	30 ,,	
1	7th February.	10th ,,	12th ,,	30 ,,	
1	10th ,,	12th ,,	,, ,,	28 ,,	
1		8th April.	18th April.	10 ,,	Submerged for 8 hours on the 16th April.
2		,, ,,	19th ,,	11 ,,	
1	9th April.	10th ,,	22nd ,,	12 ,,	
1	10th ,,	11th ,,	,, ,,	11 ,,	

The caterpillars do not hibernate, but are seen to be most active in winter. Their pupal stage is longer, however, in this season. Below are given some data which prove that they do not hibernate :—

Larvæ collected	Moths began to emerge
30th October 1905.	22nd November 1905.
21st November ,,	6th January ,,
1st December ,,	21st January 1906.
4th ,, ,,	13th January ,,
19th ,, ,,	2nd February ,,

The effect of short submergence on the resting larva and pupa is not so injurious. After eight hours' submergence, four out of five resting larvæ successfully pupated ; and moths emerged out of two pupæ which had been kept under water for eight hours. But five pupæ kept from the second day in watery mud rotted completely after eight days. The effect of hot sun is destructive to both. All of five resting larvæ and five pupæ, kept on the surface of the ground exposed to the sun in April, shrivelled up and began to dry within two days.

Imago.—Moths generally emerge at night, but in the insectary a few were noticed to emerge during the day. The obtuse end of the chrysalis bursts open and the moth creeps out of the case, with soft and crumpled wings, which, however, expand and harden very soon. The moth measures about one inch from the head to the tip of the forewings and has a wing-expanse of about two inches. When it rests, the forewings wholly cover the body, their inner or anal parts overlapping each other on the back. The sides of the wings curve downwards. The moth looks dark or blackish with some greyish patches on the back. Its habits have been noticed above. Ordinary light has no attraction for the moths. They may show a slight restlessness at the first sight of it, but they drank food and also laid eggs while the lamp was burning at a distance of about half a yard. The moths pair end to end. The interval between the emergence of the moth and the commencement of oviposition was marked in the case of only one moth. It began to lay eggs on the fourth day after emergence.

The duration of life of the moths is shown below ; males die sooner than females.

Number of moths.	When emerged.	How fed.	When died.	Duration.
3	9th January.	Kept without food.	1 on 13th. 1 on 14th. 1 on 16th.	4 to 7 days.
3	12th March.	Fed with sugared water daily.	1 on 16th. 1 on 17th. 1 on 26th.	4 to 14 days.

Occurrence as a Pest.

It has been sent in as a pest during the past three years on only a few occasions. It was reported from Monghyr as attacking opium and gram in January 1906, and at the same time from Nilgeshmari, Assam, as attacking tobacco and potato. Rungpur Farm (Bengal) experienced an attack in November 1905, and it was sent in from flooded land in Mokameh, Patna district, in December 1905. It has been sent in from Patna as attacking potato in March 1907. There are many references to this pest

in Indian Museum Notes under the name *Suffusa*. They may be tabulated as follows :—

Vol. I.	p. 33.	Jessore,	feeding on	...	...	Mustard, linseed.
„	p. 103.	Kurseong	„	...	...	Potato.
„ II.	p. 6.	Oudh	„	...	...	Poppy
„		Ghazipur	„	...	...	„
„		Fatehgarh	„	...	...	„
„ II.	p. 161.	Murshidabad	„	...	...	Wheat.
„		Tipperah	„	...	...	Barley, gram, oats, peas.
„		Patna	„	...	...	*Lathyrus sativus.*
„ IV.	p. 62.	Kashmir	„	...	...	Hops.
„ V.	p. 184.	Shahabad	„	...	...	Poppy.

As the life-history is fully dealt with above, it is unnecessary to quote from these sources. I have been unable to find any other original references to this insect in India, and no definite study of it appears to have been made. (For a successful method of treatment, see Agricultural Journal of India, Vol. II, p. 43.)

A curious feature of the insect is its occurrence in lands that have been flooded during the previous kharif season. This has been observed and has also been reported by district officers. Whether it is due to the growth of a crop of weeds on such lands, among which the larva normally lives, or due to the greater amount of moisture in the soil cannot be determined; having regard, however, to its normal habitat in waste land grown with weeds, the moth may always select such land for oviposition, and ploughing of the weedy land does not eradicate the larvæ, large full fed larvæ having been found in Pusa fields that had been ploughed and sown. This is one of the smaller class of insects which are active and breed freely throughout the cold weather in localities at a less elevation than 2,500 ft. Its activities as a pest are confined to about four months from December to March; this may not mean that these are the months when it is really most abundant, though this may prove to be so, but the explanation may be that during those months it is found in the young crops sown in lands where the moisture is greatest, whereas after the winter crops are reaped and the rains come, it is scattered over weedy

waste lands and not seen. It is not clear why the moths should be so rarely captured from June to October, but there is at present no reason to believe that the breeding is confined to the cold weather, as at first sight appeared to be the case. The fact that moths were caught in September and full-grown larvæ early in October shows that it is active in the wet months. It has been found as a pest in irrigated lucerne up to the end of May. As a pest, however, it is found almost wholly in the cold weather, and the moth-collector will, I believe, get moths most frequently then. Meyrick (Handbook of Lepidoptera) gives May to July as the months for the larva in England, August to April for the time during which the imago is found. This may be compared with the behaviour in England of *A. segetis*, Schiff, and with the behaviour of *A. flammatra* in India. It is of course a totally different history to that of the individuals recorded in India.

EXPLANATION OF PLATE XIV.

Figs. 1-8. *Agrotis ypsilon* Rott.
Fig. 1. Egg much magnified.
„ 2. Young caterpillar, magnified.
„ 3. Older caterpillar, magnified.
„ 4. The same in the natural curled attitude.
„ 5. The second and third abdominal segments, magnified
„ 6. Chrysalis, magnified
„ 7. Moth, wings expanded.
„ 8. Moth, resting attitude.
„ 9. *Agrotis flammatra*, Schiff.
„ 10. *Euxoa spinifera*, Schiff.
„ 11. *Euxoa segetis*, Hubn. (The colouring is too red

INDIVIDUAL AND SEASONAL VARIATIONS IN HELOPELTIS THEIVORA, WATERHOUSE, WITH DESCRIPTION OF A NEW SPECIES OF HELOPELTIS.

By HAROLD H. MANN, D.SC.,

Scientific Officer, Indian Tea Association.

I.—INTRODUCTORY.

The genus *Helopeltis* of the Capsidæ was formed by Signoret in 1858 to receive an insect found by Antoine Dohrn in Ceylon. It has since been brought into more prominence than almost any other among this family of heteropterous bugs, because the members of it have proved to be among the most serious pests of several cultivated tropical crops, among which are tea, cinchona, and cocoa. Their occurrence as serious pests of tea has led to the possibility of my examining many thousands of specimens of the common Indian form (*Helopeltis theivora,* Waterhouse), derived from a number of different districts, and collected at all seasons of the year. It is rare, indeed, that such an opportunity occurs for examining the morphological variations in an insect, and I trust that the details of my observations may not be entirely valueless.

It is well known that if normal examples of almost any insect are to be obtained, they must be collected and not bred. So soon as insects are brought into captivity and allowed to breed there, they are liable to extraordinary variations. This has been commonly observed in the case of the moths, but is not confined

to the order of Lepidoptera. In spite of the knowledge of this fact, very slight variations in the coloration or relative size or even of total size of insects has been considered sufficient to create a new species with a new name. In most cases this may be justifiable, but before there can be certainty whether this is so or not, it is necessary to examine a very large number of insects of the species in question existing under natural conditions, and to ascertain how far variation even under such conditions may occur within the one species. This has, in most cases, not been done from lack of material, for many species have been named from single type specimens, but even where possible has rarely indeed been carried out. The result has been that the same species has, in many cases, been named over and over again, and that entomology is cumbered with a multitude of names which represent mere individual or seasonal variations of a single insect.

II.—HISTORICAL.

The original description of the genus *Helopeltis* runs as follows :—

"Genre 'Helopeltis,' Signoret.

De même forme que le genre précédent (*Pachypeltis*), il s'en distingue facilement par l' aspect de l'ecusson qui présente sur son disque une épine. Antennes avec le premier article aussi long que la tête et le prothorax : second article le plus long : troisième et quatrième courts. Abdomen débordant les élytres."

The most recent description of the same genus (*Distant, Fauna of British India. Rhyncota, Vol. II, p.* 439), is as follows :—

"Body elongate ; head broad, deflected in the front of eyes, discally and centrally longitudinally incised or sulcated: antennæ inserted in front of, but on a level with the inner margin of the eyes, with the first joint about as long as the head and pronotum together ; its apex moderately incrassated ; pronotum strongly constricted before the middle, posterior margin more than twice the width of anterior ; scutellum with a long more or less erect horn or spine, its apex clavate ; legs moderately long and slender, femora nodulose."

In one point the description of the genus by Signoret must be corrected. This refers to the length of the joints of the antenna. Usually the second and third joints are of nearly equal length in *Helopeltis theivora*, in the males the third being usually slightly longer than the second, while in the females the opposite is the case.

The specific characters of *Helopeltis theivora* were thus described by Waterhouse in 1886 :—

" Female—Black, thorax orange yellow, with a black line near the front margin, the base margined with black. Scutellum brown, black at the base, the horn long, much curved, black, brown at the apex. Antennæ dark brown, the basal joint paler, yellow at the base. Femora dark brown, mottled with light brown, with a light yellow ring at the base. Tibiæ light brown, speckled with dark brown. This species is at once distinguished from the two preceding species (*Helopeltis Antonii* and *Helopeltis Bradyi*) by the longer and curved horn on the scutellum."

He adds that Peal states when full grown " the colour deepens " and " it turns black on the head and thorax. " Waterhouse remarks also that it has the scutellar horn longer and stouter than *Helopeltis antonii*, and that it may easily be distinguished by this means.

The next writer on the subject (Atkinson, *Indian Museum Notes, Vol. I, p.* 175 (1890)), simply repeats Waterhouse's description without making any addition.

Dudgeon (*Indian Museum Notes, Vol. III, No.* 5, *pp.* 34-35 (1896)), added considerably to this description, by giving an account of the oviposition and of the ovipositor. Of the latter he says : " The ovipositor . . . . is more than half as long as the rostrum. It is difficult to distinguish it on the underside of the abdomen, folded, as it is, close against the dark shiny surface which it matches well in colour ; but if the body be pressed, it rises from the surface and can be distinctly seen with the naked eye. It is in the form of a curved, corneous process rising from the centre of the sixth abdominal segment on the underside, and reaching to the eighth segment. Its colour, like that of the posterior abdominal segments, is dark brown.

" It will be seen by referring to Mr. Waterhouse's description of the insect that no mention is made of the colour or markings of the abdomen, although the latter are well shown in the plate given with it. I, therefore, conclude that the description was made from dried specimens from which the colour had gone, as

soft-bodied insects do not preserve it long. The abdomen in fresh specimens of both sexes is invariably bright emerald green by transparency, marked dorsally on the third to ninth segment with shiny dark brown. The extent of brown on the third segment is limited to a small dorsal patch, or is altogether absent : on the fourth it extends over the whole dorsal region : on the fifth, partially lateral and wholly dorsal, the remaining segments are all dark brown ; the segmental divisions are greenish. The male differs from the female in having the pronotum very slightly tinged with yellow : the abdomen more slender and the absence of the ovipositor."

Except for a short publication by the present author in 1903 (*Indian Museum Notes, Vol. VI, No.* 1), the only further formal description on record is that by Distant (*Fauna of British India, Rhyncota, Vol. II, page* 440). His account is as follows :—

"Male—Head and pronotum shining black, much resembling the same sex of the preceding species (*H. antonii*), but with the scutellar horn more curved backward at apex.

"Female—Black, pronotum bright shining stramineous or ochraceous, with a subapical transverse fascia and the basal area shining black ; scutellum ochraceous, more or less suffused with black, the horn long, black, piceous at apex ; antennæ dark brown, basal joint paler, yellowish at base ; femora dark brown, mottled with ochraceous, and with a distinct pale annulation near base ; tibiæ ochraceous speckled with fuscous ; head beneath with a lateral luteous fascia on each side, more obscurely seen above : abdomen pale creamy ochraceous, the apical third black."

Distant attaches great importance in specific classification to the amount of bending of the scutellar horn. This, he says, is nearly straight and perpendicular in *Helopeltis antonii*, and more or less distinctly curved backwards in *Helopeltis theivora*.

It will be seen that these various descriptions do not by any means agree in every point. In fact, from them it would appear almost impossible to discriminate between the several species. Thus in an early stage of the present investigation I found the bending of the scutellar horn, on which Distant lays stress, one

of the most variable features of the insect. Many examples were found, more especially among the males of *Helopeltis theivora*, whose scutellar horn was hardly, if at all, bent, while others, especially among the females, had it bent very markedly. The colour variations were almost numberless; the tints of the pronotum ranged from a very dark ochraceous almost red, to a very slight straw colour. The amount of colour also varied markedly. I have had insects, especially females, in which there was not a mark of black (except the eyes), throughout the whole insect, while others have had almost as little ochraceous or green as a male.

III.—GENERAL METHOD OF STUDY.

The method by which I have studied the variations is as follows. By the kindness of some of the planters of the Indian tea districts, I have been supplied with the whole of the adult insects caught in various months of the year on their property, feeding on the tea bushes. In one case,—Behalli, Durrung, Assam,—I have had them sent to me for *every* month in the year, preserved in weak spirit. Experience has shown that this method of preservation has little effect, except to dull it slightly, even on the colour, and that the insects can be so kept for examination for a very long time. The males and females, which are easily distinguishable (*vide* my paper on the relative proportion of the sexes

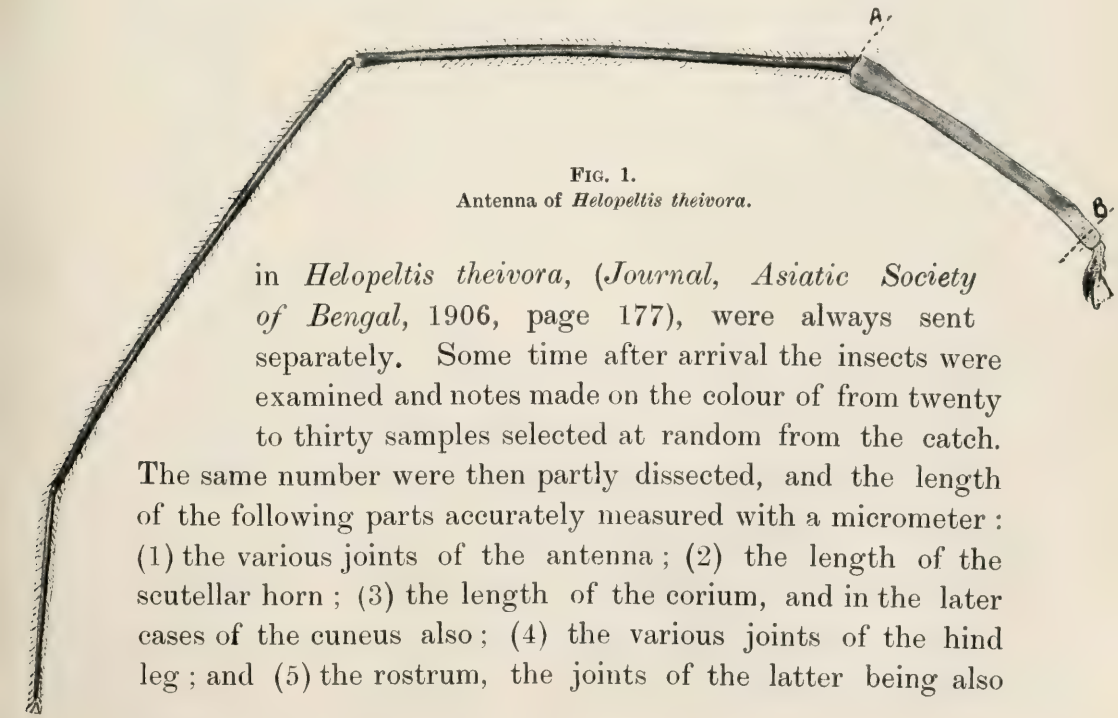


Fig. 1.
Antenna of *Helopeltis theivora*.

in *Helopeltis theivora*, (*Journal, Asiatic Society of Bengal*, 1906, page 177), were always sent separately. Some time after arrival the insects were examined and notes made on the colour of from twenty to thirty samples selected at random from the catch. The same number were then partly dissected, and the length of the following parts accurately measured with a micrometer: (1) the various joints of the antenna; (2) the length of the scutellar horn; (3) the length of the corium, and in the later cases of the cuneus also; (4) the various joints of the hind leg; and (5) the rostrum, the joints of the latter being also

measured in a few cases. In the case of one fairly typical individual in most of the sets of insects, there were measured in addition, (1) the intermediate leg; (2) the foreleg; (3) the maximum length of the hemelytra; (4) the length of the head and pronotum together. In order to make absolutely clear what the figures mean, it will be necessary to state exactly the lengths that were measured.

1. *Antenna.*—In measuring the first joint of the antenna, a difficulty arose as to what to take as the point of origin, which was difficult to define in a dissected organ. I ultimately found that by far the most definite results could be obtained by commencing the measurements from a slight constriction in the antenna, which occurs just after the organ leaves the head, as shown at B in the figure attached. The other joints presented no difficulty.

FIG. 2.
Scutellar Horn of *Helopeltis theivora.*

2. *Scutellar Horn.*—The difficulty of defining the point of origin of the scutellar horn was so great that I ultimately gave up measuring it; and figures have only been recorded for the earlier months. When measured, the measurement was made from *a* to *b* in Figure 2.

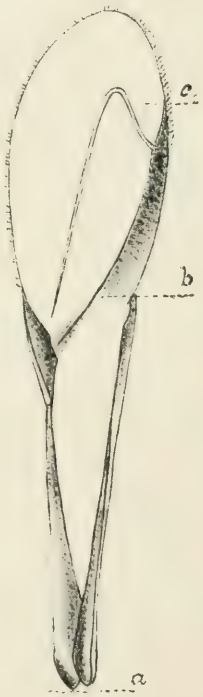


FIG. 3.
Hemelytron of *Helopeltis theivora.*

3. *Corium* and *Cuneus.*—It was possible to make these measurements very accurately, the particular points taken being shown in Fig. 3. *a* to *b* representing the length of the corium, and *b* to *c* the cuneus.

4. *Legs.*—The measurement of the legs presented some difficulty. It was ultimately decided to take the length of the femur with the trochanter, making allowance for the curvature. This allowance

amounted normally to the addition of ·06 millimeters to the length actually measured. The root end of the tibia was difficult to define, as it was always bent over at the point of junction with the femur. Fig. 4 shows the points ultimately adopted for the purpose, and it was usually, but not always, marked by the presence of a longish hair.

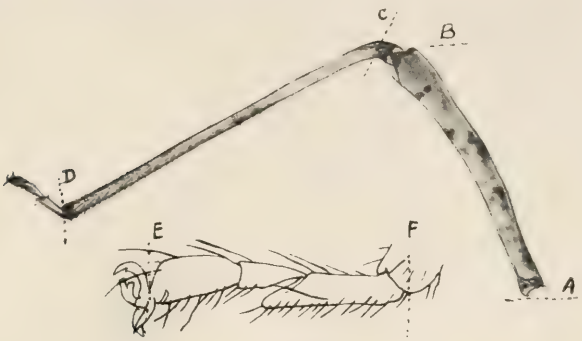


FIG. 4.
Hind leg of *Helopeltis theivora*.

5. *Rostrum.*—The whole of the four joints were measured, the point of origin being usually easy to locate. See Fig. 5.

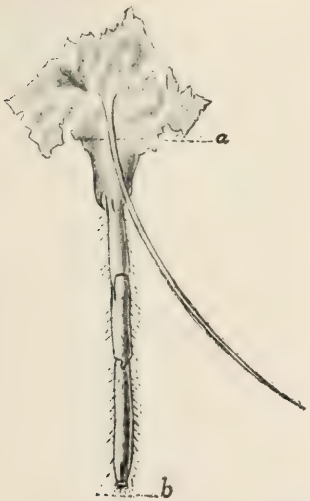


FIG. 5.
Rostrum of *Helopeltis theivora*.

The measurement of the remaining parts presents no difficulty.

A number of tests were made in order to ascertain how nearly the measurements were accurate. It was found that they could always be relied on to ·06 millimeter, though most were within ·03 millimeter.

The variations in the insect can perhaps best be described by indicating what are the typical characters of the principal parts of the insect, and then describing the amount of variation which I have noticed in individuals.

IV.—INDIVIDUAL AND SEASONAL VARIATION OF THE MALE.

Head.—Typically the head is "Broad, deflected in front of eyes, discally and centrally longitudinally incised or sulcated. Antennæ inserted in front of but on a level with the inner margins of the eyes." (Distant, *l. c.*). Just inside the insertion of each of the antennæ, there is a minute but very marked tubercle, black, about ·06 mm. long. The whole is black both above and below.

Variations.—The variations principally affect the colour, which may be anything from bright shining black to a mere suffusion of black over ochraceous. The eyes are always black. A small ochraceous lateral fascia is very common.

Antennæ.—The antennæ consist of four joints, the second, third and fourth being a shining brownish black, while the first is dark brown with a basal yellowish ring. This first joint is moderately thickened at the apex. The average length of the several joints comes out as follows :—

	January to April.	May to December.
	mm.	mm.
First joint	2·31	2·50
Second joint	4·31	4·56
Third joint	4·42	4·70
Fourth joint	1·63	...

The fourth joint is very easily broken off, and it is rarely that it is present in caught samples. The whole antenna is, however, very much tougher than in the female, where even the third joint is very often broken off in catching the insects. The whole of the second, third and fourth joints are hairy, the hairs reaching a length on the second joint of ·08 mm.

Variations.—The colour variations of the antennæ are very slight.

The differences in the size of the various joints are, however, very great, and this applies to individuals occurring in the same month, and in a much greater measure to individuals in different times of the year. It will be well in this matter to take each joint of the antenna separately, and show the extreme variations, the prevailing size, and the general average for each month.

(*a*) *First joint of Antenna.*

Month.	Longest specimen.	Shortest specimen.	Prevailing size.	General average.
	mm.	mm.	mm.	mm.
January	2·67	1·90	2·30—2·33 and 2·50—2·53	2·29
February	2·37	1·83	1·90—1·93 and 2·10—2·20	2·08
March	2·53	2·13	2·27—2·37	2·31
April	2·70	2·37	2·53—2·66	2·58
May	2·77	2·47	2·53—2·63	2·57
June	2·83	2·30	2·43—2·53	2·49
July	2·67	2·30	2·43—2·60	2·48
August	2·70	2·30	2·50—2·60	2·52
September	2·70	2·37	2·47—2·53 and 2·63	2·53
October	2·80	2·20	2·47—2·60	2·51
November	2·67	2·13	2·37 and 2·43—2·53	2·44
December	2·67	2·17	2·30—2·40 and 2·47—2·50	2·41

(*b*) *Second joint of Antenna.*

Month.	Longest specimen.	Shortest specimen.	Prevailing size.	General average.
	mm.	mm.	mm.	mm.
January	5·03	3·60	4·20—4·27 and 4·53—4·63	4·34
February	4·23	3·57	3·93—4·17	3·94
March	4·63	3·97	4·17—4·37	4·28
April	5·00	4·44	4·60—4·67 and 4·73—4·77	4·69
May	5·57	4·20	4·47—4·53 and 4·60—4·67	4·66
June	5·00	4·23	very variable from 4·17—4·87	4·56
July	5·43	3·83	4·40—4·57	4·46
August	5·63	3·93	4·63—4·70	4·59
September	5·03	4·23	4·50—4·63	4·60
October	4·97	4·10	4·53—4·60 and 4·73—4·80	4·59
November	5·10	3·87	no prevailing size, most at 4·57	4·52
December	4·87	3·90	4·33—4·37 and 4·50—4·60	4·50

(*c*) *Third joint of Antenna.*

Month.	Longest specimen.	Shortest specimen.	Prevailing size.	General average.
	mm.	mm.	mm.	mm.
January	4·87	3·73	4·47—4·67	4·36
February	4·43	3·77	3·97—4·20	4·03
March	4·77	4·27	4·37—4·47	4·46
April	5·00	4·66	4·66	4·83
May	4·90	4·40	4·60—4·70	4·66
June	5·23	4·37	4·50—4·70	4·69
July	4·93	4·03	4·77—4·90	4·66
August	5·03	4·40	4·77—5·00	4·76
September	5·03	4·47	4·77—4·90	4·76
October	5·13	4·53	4·53—4·77	4·77
November	5·10	4·07	4·47—4·60	4·66
December	4·80	4·33	4·53—4·63	4·60

(*d*) *Fourth joint of the Antenna.*—Sufficient of these were not obtained to allow the figures being set out in detail. Those measured varied from 1·70 mm. to 1·58 mm.

From a consideration of these figures it seems that the following conclusions can be drawn.

1. That there is a large variation in the measurements of the antennæ of individual insects collected in the same month. This amounts to an increase in the length of each of the three measured joints as follows. The percentages given show the percentage by which the longest is longer than the mean, and the shortest shorter than the mean.

	First Joint.		Second Joint.		Third Joint.	
	Extreme variation above mean.	Extreme variation below mean.	Extreme variation above mean.	Extreme variation below mean.	Extreme variation above mean.	Extreme variation below mean.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
January	16·5	17·0	15·9	17·0	11·7	14·5
February	14·0	12·0	7·4	9·4	10·0	6·5
March	9·6	7·8	8·1	7·2	7·0	4·2
April	4·6	8·1	6·6	5·3	3·5	3·5
May	7·8	3·9	19·5	10·0	5·1	5·5

	First Joint.		Second Joint.		Third Joint.	
	Extreme variation above mean.	Extreme variation below mean.	Extreme variation above mean.	Extreme variation below mean.	Extreme variation above mean.	Extreme variation below mean.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
June	13·6	7·6	9·7	7·2	11·5	6·8
July	7·6	7·3	21·7	14·1	5·8	13·4
August	7·2	8·8	22·6	14·3	5·6	7·5
September ...	6·7	6·3	9·4	8·0	5·6	6·0
October ..	11·6	12·4	8·3	10·6	7·5	5·0
November ...	9·4	12·7	12·9	14·4	9·4	12·5
December ...	10·8	10·0	8·2	13·3	4·3	5·9

Thus in the same month individuals may differ from the mean by over twenty per cent. in the length of one of the joints of the antennæ, and still be within the single species *Helopeltis theivora*.

2. That there is a regular variation with the seasons. The shortest antennæ among the males are found in February in Upper Assam. From this time the length rapidly increases till April, and then remains almost constant until November or December. The maximum, minimum and mean length for each joint for the whole season is approximately as follows :—

	Maximum.	Minimum.	Mean.
	mm.	mm.	mm.
First joint	2·83	1·83	2·43
Second joint	5·57	3·57	4·48
Third joint	5·23	3·73	4·60

3. That combining individual and seasonal variations of the antennæ, we find that—

(*a*) the first joint varies from 12·3 per cent. above the mean to 24·7 per cent. below it ;

(*b*) the second joint varies from 24·3 per cent above the mean to 20·3 per cent. below it ;

(*c*) the third joint varies from 13·7 per cent. above the mean to 18·9 per cent. below it.

Rostrum.—Last among the parts attached to the head to be described is the rostrum, consisting of four joints and coloured obscure ochraceous, the tip being dark brown—nearly black on

occasions. It is sparsely scattered with hairs, and the tip is very hairy. The average length of the rostrum and of its joints is as follows:—

Length of Rostrum	1·73	millimetres.
„ „ base joint (by difference)	·39	„
„ „ second joint from base	·38	„
„ „ third joint from base	·38	„
„ „ tip joint	·58	„

In life the rostrum is held, at rest, parallel to the body, and reaches exactly to the intermediate coxæ.

Variations.—The rostrum forms one of the most constant parts of the body, both in colouring and in size. Beyond slight variations in the amount of the dark brown colour characteristic of the tip, it may be said to hardly ever differ in colour from the typical form just described. The size is also remarkably uniform. Differences, both individual and seasonal, do occur, and, so far as the length of the whole rostrum is concerned, are shown in the following table:—

Month.	Longest specimen.	Shortest specimen.	Prevailing length.	General Average.
	mm.	mm.	mm.	mm.
January	1·83	1·57	1·67—1·70	1·69
February	1·90	1·53	1·63—1·73	1·67
March	1·80	1·63	1·70—1·73	1·72
April	1·87	1·63	1·70—1·77	1·74
May	1·83	1·60	1·70—1·77	1·74
June	1·87	1·63	1·70—1·77	1·74
July	1·87	1·60	1·70—1·77	1·73
August	1·90	1·63	1·73—1·77	1·76
September	1·87	1·67	1·73—1·80	1·76
October	1·83	1·67	1·77—1·80	1·76
November	1·93	1·67	1·73—1·80	1·75
December	1·83	1·63	1·73	1·73

Seeing that the possible error of each observation is about ·06 mm., the certain conclusions to be drawn from these figures are—

(1) that the only seasonal variation is a reduction in average size in the cold weather of about 3·5 per cent., the minimum being reached in February;

(2) that the individual variation is much greater than the seasonal variation, but the number of exceptional individuals is

small, the very large majority in any one month lying between the limits of experimental error.

The length of individual joints of the rostrum was only determined for a few months, and then only by examination of five individuals in each month. The figures obtained were, however, as follows :—

Month.	2nd Joint.	3rd Joint.	Tip Joint.
	mm.	mm.	mm.
February	·37	·35	·56
March	·38	·39	·59
August	·39	·39	·59
September	·41	·40	·59
October	·35	·38	·58
December	·39	·39	·59

No further conclusion as to the variation of these items can be drawn, but, on the whole, they confirm those indicated above for the whole rostrum.

Pronotum.—The typical pronotum in the male of *Helopeltis theivora* has never been formally described. It conforms to the general characters of this part of the body in the genus by being "strongly constricted before the middle," while the posterior margin is "more than twice the length of the anterior" (Distant). It sometimes agrees in colouring with the characters given for *Helopeltis antonii* ("anterior margin narrowly obscurely ochraceous" (Distant), but the colouring is exceedingly variable. My remarks on the variations of the pronotum will be entirely concerned with the changes in colouring. These changes have only been observed for four of the months in the year. I shall call the part of the pronotum anterior to the constriction the 'collar.'

The colouring of the collar was only observed for a series of samples in March, August, September, and December.

(*a*) In March, of twenty-five samples examined, ten had the whole of the collar black, nine wholly ochraceous, one ochraceous with a black spot in the middle, and five had an undefinable mixture of black and ochraceous.

(*b*) In August, there were nine samples with the collar black, fourteen with it ochraceous, and two with an undefinable mixture.

(*c*) In September, there were fourteen with a black and nine with an ochraceous collar, while the remaining one had a black spot in the middle of an ochraceous collar.

(*d*) In December, the collar was black in eleven cases and completely ochraceous in none. In nine cases the anterior portion was ochraceous, while the posterior was black, while the colour was undefinable in the remainder.

In general one may say that the colour of the collar of the pronotum is extremely variable. Perhaps there is a greater tendency to ochraceous in the height of the season, and to black during the colder and less active time of the year.

The remainder of the pronotum is equally variable in its colour markings. Typically it may be said to be black with a large ochraceous spot on each side slightly anterior to the middle, but the range of variations includes a completely black pronotum, and one where the whole anterior portion is ochraceous. Taking the same months as given above, the following variations have been observed :—

(*a*) In March, out of 25 samples, eleven were of the kind described above as typical, though the size of the ochraceous spots was very variable. In fourteen cases, the ochraceous spots join in the middle, forming a band varying in width in the centre from one-eighth to one-half the width of this portion of the pronotum.

(*b*) In August, ten samples were typical, four had an ochraceous band of variable width right across ; and eleven had the portion of the pronotum now under discussion, entirely black.

(*c*) In September, only five samples (out of twenty-four) were typical, three had the ochraceous band right across the pronotum, and sixteen were entirely black.

(*d*) In December, on the other hand, sixteen insects (out of twenty-five) were typical, but with ochraceous spots very variable

in size, sometimes nearly meeting in the centre: eight had the ochraceous band right across: and only one was entirely black.

These notes seem to indicate a tendency to be blacker in the height of the season, a conclusion which is the reverse of that which appears to obtain for the anterior part ("collar") of the pronotum.

Head and Pronotum.—Before passing on to consider the scutellum, I may note an error which seems to recur in nearly all the descriptions of the insect, that "the first joint of the antennæ is about as long as the head and pronotum together" (Distant). In reality it is much longer. I have already stated that the first joint of the antenna is, as a mean for the whole year, 2·43 millimetres long. The combined length of the head and pronotum (excluding the scutellum) is, in various months, as follows:—

Month.	Combined length of head and pronotum.
	mm.
January	1·47
February	1·33
March	1·53
August	1·53
September	1·57
October	1·62
December	1·63

It should be noted, however, that these measurements were of single individuals during these months, and are not average values.

Scutellum.—I have not been able to investigate the colour variations of the scutellum itself. Typically it is, as Distant describes (l. c.), for *Helopeltis antonii* "black, testaceous at apex." The scutellar horn is, however, a point of great interest. The drumstick-shaped horn is characteristic of the genus, and has been used as a mark of specific differences. Waterhouse distinguished *Helopeltis theivora* from *Helopeltis antonii* by the fact that the former has "the scutellar horn longer and stouter," and also by the fact that in the former case it is said to be bent. Distant makes the amount of bending in the horn a primary division of the genus. Hence one would expect that both in size

and shape it would be of the most constant character. As a matter of fact, it is extremely variable, in size, colouring and shape. In size the specimens for different months vary, on the averages, by at least fifteen per cent. in length; in colouring it varies from being almost entirely ochraceous with two small black patches to being entirely black; in shape it varies from being bent backwards very strongly to possessing hardly a perceptible curve. I will deal with these variations in succession.

Though as I have said before (page 5) the scutellar horn is difficult to measure owing to the indefinite character of its lower termination, yet results which are probably of fair accuracy have been obtained for a number of months. These are as follows :—

Month.	Length of Scutellar Horn.		
	Longest.	Shortest.	Mean.
	mm.	mm.	mm.
January	1·43	1·03	1·23
April	1·25	1·03	1·19
May	1·43	1·17	1·32
June	1·47	1·20	1·35
July	1·47	1·13	1·33
October	1·53	1·13	1·37
November	1·40	1·13	1·30

The difference in the mean due to season works out at fifteen per cent., calculated on the figure for April. The variations from the mean of individuals in each month is a little greater, as follows :—

Month.	Variation of Scutellar Horn from Mean.	
	Variation of Longest.	Variation of Shortest.
	Per cent.	Per cent.
January	16·3	16·3
April	5·0	13·5
May	8·3	11·4
June	9·0	11·1
July	10·5	15·0
October	11·7	17·9
November	7·7	13·1

The colour variations are quite as marked. In what one may perhaps consider the typical form, the scutellar horn is black

with a broad brownish or brownish-ochraceous ring round the middle, and with the tip ochraceous or luteous. The variations from this in a few selected months in the year are as follows :—

(*a*) In March, out of twenty-two horns examined, eighteen were typical as just described, the remaining four being entirely black, except for a tip varying in colour from ochraceous to luteous.

(*b*) In August, out of twenty-four horns examined, twenty-one were typical ; of the remaining three, two were entirely black with the tip luteous, and the other one had the whole of the upper part of the horn ochraceous, with a lighter shaded tip.

(*c*) In September, out of twenty-three specimens, nineteen were typical, two were entirely black, except the ochraceous tip, and two were black throughout (the ochraceous ring being almost or entirely obsolete), including the tip.

(*d*) In December, twenty-two horns were examined. Of these, sixteen were typical, four were black with the tip ochraceous, and two were black or nearly black throughout, including the tip.

The amount of bending of the horn was difficult to describe. That of the males was almost always less than that of the females (*vide infra*), and I have classed them as 'hardly bent,' 'slightly bent,' and 'distinctly bent.' No stronger bending than this was found in any case.

Month.	Scutellar Horn.		
	Hardly bent.	Slightly bent.	Distinctly bent.
	Per cent.	Per cent.	Per cent.
March	17	78	5
August	8	60	32
September	4	58	38
December	36	64	...

These last figures are, of course, liable to a personal error of observation, being classed at different times, but in general, I think, they are sufficiently near to indicate that there is an enormous variety in the amount of bending in the scutellar horn, and that on the whole it is more bent in the height of the season than at other periods.

Such results as I have here recorded seem to dispose very largely of any claim which might be possessed by the scutellar horn to be a basis of classification of the species of *Helopeltis* in any way.

At this point, it may be well to correct the statement in nearly all authorities that the tip of the scutellar horn is cupshaped. This it certainly is usually in dried specimens, but in fresh insects it is clavate and covered with short hairs, among both males and females.

Wings.—The typical hemelytron is long and rather drumstick-like in shape. The clavus is well developed but triangular in shape, being widest at the root of the wing. The corium is not hard, being little thicker than the remaining part of the wing; it passes into the cuneus without any division. The cuneus is brownish in colour, the remainder of the wing, except the veins, being pale transparent. The membrane has only one irregularly shaped vein. The wing membrane is covered with microscopic hairs, and the edge is very distinctly hairy.

The typical hindwing calls for no special remark. It is transparent throughout, with two spur-like veins in the membrane, and is about I millimetre shorter than the hemelytron. I have not studied its variations.

The hemelytron is one of the most constant parts of the male *Helopeltis* insect, and it shares to only a very small extent in the reduction in size in the early part of the year. I have measured the length of the corium in a series of samples in each month, the length of the cuneus in two months, and the maximum length of the hemelytron in typical individuals in most of the months.

The maximum length of the wing and that of the corium in the same individuals gave measurements as follows :—

Month.	Maximum length of forewing.	Length of corium.
	mm.	mm.
January	4·70	2·73
February	4·60	2·77
March	4·60	2·77
August	4·63	2·90
September	4·60	2·87
October	4·73	2·83
December	4·87	2·90

The length of the corium in the several months came out as follows :—

Month.	Longest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January	3·13	2·51	2·78
February	2·93	2·50	2·71
March	3·00	2·70	2·82
April ...	3·06	2·74	2·88
May	2·90	2·67	2·80
June	2·90	2·67	2·79
July	2·90	2·53	2·74
August	2·90	2·63	2·76
September	2·93	2·67	2·78
October	2·90	2·60	2·79
November	3·00	2·67	2·83
December	3·00	2·60	2·79

It will be noticed that these figures are remarkably constant. The monthly means do not vary more than $4\frac{1}{2}$ per cent. Individuals in each month vary considerably more than this, showing that we have to do more with an individual than with a seasonal variation. The differences between the largest and smallest wings in January and February are, however, wider than is the case in any other month, indicating that the colder weather or the conditions of life then has a tendency to destroy uniformity. The differences from the mean are shown in the following table :—

	Differences from mean.	
Month.	Longest specimen.	Shortest specimen.
	%	%
January	12·5	9·6
February	8·1	7·8
March	6·4	4·3
April	6·2	4·8
May	3·6	4·6
June	4·0	4·3
July	5·9	7·6
August	5·1	4·7
September	5·4	3·9
October	3·8	6·8
November	6·1	5·7
December	7·5	6·8

The relative length of the corium and cuneus has been determined also for all samples for one month (December). The figures gave (mean) 2·79 mm. for the corium and 1·14 mm. for the cuneus, or a relationship of just under $2\frac{1}{2}$ to 1.

Legs.—The legs of the male of *Helopeltis theivora* have never been described in detail. Distant remarks that they much resemble "those of the preceding species" (*Helopeltis antonii*). The latter are stated to be "brown, speckled with ochraceous, the bases of the femora distinctly ochraceous." The general characteristics of the legs of this genus are, moreover, indicated as follows :—"Legs moderately long and slender, femora nodulose."

The three legs are, in fact, extremely similar in form and colouring, the fore and intermediate legs approximately the same size, and smaller in every respect than the hind leg. Their colouring is as described by Distant, and merely varies slightly in the amount of dark and light colouring found in different samples. The femora are distinctly nodulose, slightly incrassated at the apex, and the trochanter (which I have measured with the femora) is about ·19 mm. long on the inner side in the hind leg. The tibia is straight and very hairy at the lower part. The tarsus is composed of three joints; of these the first is very large and hairy and overlaps considerably the second joint. This last is small, not being half the size of the first joint. The third is intermediate in length, and, like the other two, very hairy. The last joint bears two claws on each side of the tarsus.

My systematic measurements have principally dealt with the hind leg, but in a large number of cases, I have measured the fore, intermediate and hind legs of the same individual. The results thus obtained are as follows :—

Month.	Fore leg.			Intermediate leg.			Hind leg.		
	Femur.	Tibia.	Tarsus.	Femur.	Tibia.	Tarsus.	Femur.	Tibia.	Tarsus.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
January	1·87	2·50	·50	1·87	2·43	·47	2·40	3·00	·50
February	1·83	2·43	·43	1·83	2·33	·43	2·27	2·90	·47
March	2·00	2·53	·50	1·97	2·47	·50	2·43	3·00	·53
August	2·17	2·73	·53	2·13	2·67	·53	2·60	3·30	·50
September	2·17	2·70	·50	2·13	2·70	·50	2·60	3·30	·57
October	2·03	2·67	·50	2·05	2·53	·50	2·50	3·13	·53
December	2·07	2·60	·50	2·07	2·53	·53	2·50	3·07	·50

It will be seen that all the legs share the seasonal reduction in the size undergone by the other appendages to the insect, which occurs in January and February. This is illustrated more completely by the larger series of observations, embracing many samples from every month of the year, on the hind leg. The results are shown in the following table :—

Month.	Length of Femora.			Length of Tibiæ.			Length of Tarsus.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
January	2·63	2·20	2·38	3·37	2·80	3·01	·57	·43	·51
February	2·33	1·93	2·20	3·00	2·53	2·80	·50	·43	·48
March	2·50	2·23	2·38	3·20	2·77	2·99	·53	·47	·51
April	2·66	2·40	2·51	3·33	3·00	3·18	·63	·50	·53
May	2·70	2·47	2·59	3·33	3·03	3·17	·57	·50	·51
June	2·83	2·40	2·57	3·40	2·97	3·20	·57	·47	·53
July	2·70	2·30	2·49	3·37	2·87	3·13	·57	·47	·52
August	2·70	2·30	2·54	3·37	2·90	3·20	·57	·47	·53
September	2·73	2·40	2·55	3·37	3·03	3·21	·57	·50	·54
October	2·67	2·23	2·51	3·33	2·80	3·14	·57	·47	·52
November	2·63	2·27	2·51	3·37	2·83	3·13	·53	·47	·52
December	2·67	2·23	2·41	3·33	2·90	3·09	·57	·47	·51

From these figures it will be seen that the individuals vary to a very great extent. The limits are—

(1) for the femora—2·83 mm. to 1·93 mm. or nearly nineteen per cent. above or below the mean ;

(2) for the tibiæ—3·40 mm. to 2·53 mm. or nearly fifteen per cent. above or below the mean ;

(3) for the tarsi—·63 mm. to ·43 mm. or nearly nineteen per cent. above or below the mean.

The seasonal variation of the mean is almost as great. From sizes of 2·20 mm., 2·80 mm., and ·48 mm. for the femur, tibia and tarsus respectively in February, a rise occurs to 2·55 mm., 3·21 mm., and ·54 mm. in September. It is, however, interesting to note that the hind leg has given markedly constant figures from April to November, and that a noticeable decrease in size occurs in December, becoming greater in January. The minimum is reached in February, after which a slow increase takes place till the size becomes once more normal in April.

Thorax.—I have not made any detailed observations on the thorax, but in general it may be said that there is a very marked furrow down its centre going as far back as the intermediate coxæ. Its typical colour is perhaps black, but all stages from a black suffusion on an ochraceous ground to a complete black thorax are found. All the coxæ are always luteous, however, in my experience.

Abdomen.—The underside of the abdomen is described by Distant (under *Helopeltis antonii*) as "luteous, with a basal spot and the apex black." None of these characters can be considered as constant. The colour varies from ochraceous to luteous through green. A shade of green is by far the most common. The basal spot is not always found. The apex is certainly black in the majority of cases, but in every month there are a number of insects in which it is the same colour as the remainder of the abdomen. This is, probably, in part determined by the length of time from hatching out of the adult, but this will be discussed later in speaking of the female.

The upper part of the abdomen has typically the apex black, and black patches on the next four segments, the patches gradually decreasing in size on each successive segment from the tip. The amount of black is a very variable character. Occasionally the whole upper part of the abdomen is ochraceous, greenish luteous, or green as the case may be, except the tip. Occasionally there is a slight suffusion of black only on several segments. The following is a record of some of the observations made :—

In March, out of twenty samples, thirteen were typical with black patches on four segments as well as the tip, three had black on three segments, two had black on two segments, one had black on one segment, one had only the tip black.

In August, out of twenty samples, twelve were typical, six had black on three, one had black on one, and the remaining one had no black on any segment except the tip.

In September, out of nineteen samples, only ten were typical. Five insects had black on three segments, two insects on two segments, one insect on one segment, while one had no black except on the tip.

December, out of twenty-five samples, seventeen were typical. Two insects had black on *five* segments, three on three segments, one on two segments, and two on one segment only.

Enough has, therefore, been said to show how exceedingly variable is the colouring of the abdomen. From the above observations it would appear probable that there is more black on the abdomen in the colder weather of December to March, but even this is by no means certain.

It is now perhaps possible to draw up a description of the male of *Helopeltis theivora* as occurring on tea in Assam, and show the extent of the variations which may occur under these circumstances. The following is an attempt to do so :—

Part of insect.	Typical characters.	Extent of variation found.
HEAD ...	Broad, deflected in front of eyes, discally and centrally longitudinally incised or sulcated. Antennæ inserted in front of but on a level with the inner margin of the eyes. Minute tubercle just inside insertion of antennæ. Colour—black.	Tubercle not always visible. Colour varies from ochraceous with slight suffusion of black to completely black. Eyes always black. Head often has a lateral ochraceous fascia on each side.
ANTENNÆ ...	Four-jointed.	
	First joint is dark brown with a basal yellowish ring and as a mean is 2·40 mm. (mean) long. It is slightly incrassated near apex.	Length varies from 2·83 mm. (June) to 1·83 mm. (February).
	Second joint is shining brownish black, thinner than base joint and 4·44 mm. (mean) long. Very hairy.	Length varies from 5·57 mm. (May) to 3·57 mm. (February).
	Third joint is similar to second, but slightly thinner, and 4·56 mm. in length (mean).	Length varies from 5·10 mm. (November) to 3·73 mm.
	Fourth joint is similar to the third, but again thinner and 1·63 mm. in length (mean).	Length varies from 1·70 mm. to 1·58 mm.
ROSTRUM ...	Four-jointed, and coloured obscure ochraceous, the tip being dark-brown.	Tip may be almost black.
	It has hairs sparsely scattered over it, and tip is very hairy. In life reaches to intermediate coxæ.	
	Average length— Whole rostrum ... 1·73 mm. Second joint ... ·38 mm. Third joint ... ·38 mm. Tip joint ... ... ·58 mm.	Length of rostrum varies from 1·93 mm. (November) to 1·53 mm. (February).
PRONOTUM ...	Strongly constricted before middle forming a distinct collar. Posterior margin more than twice the length of anterior.	
	Collar is either black or ochraceous or mixed.	Collar tends to be ochraceous in growing season, and black in cold weather.

Part of insect.	Typical characters.	Extent of variation found.
PRONOTUM ...	Remainder of pronotum variable, but most typically black with ochraceous spot on each lateral surface.	Remainder of pronotum varies from entirely black, to black with a wide ochraceous band right across anterior portion. Tendency to be blacker in height of growing season.
HEAD and PRONOTUM.	Combined length 1·53 mm.	Combined length varies from 1·63 mm. (December) to 1·33 mm. (February).
SCUTELLUM ...	Black, Testaceous at apex.	
SCUTELLAR HORN.	Black with ochraceous ring round middle and ochraceous tip. Tip spherical and very hairy. Slightly bent backwards. Length 1·30 mm. (mean).	Colour varies from entirely black to black with a very wide ochraceous ring. Tip may be black. Amount of bending extremely variable. Length varies from 1·53 mm. (October) to 1·03 mm. (January).
WINGS, — HEMELYTRON.	Long, drumstick in shape. Clavus well developed. Corium not hard but membranous, passing into cuneus without division. Length 2·79 mm. (mean). Cuneus, brown, narrow, and 1·14 mm. long (mean). Maximum length of wing, 4·70 mm. Membrane with one irregular vein.	Corium varies in length from 3·13 mm. (January) to 2·50 mm. (February). Wing length varies from 4·87 mm. to 4·60 mm.
HINDWING ...	Colourless with two spur-like veins in membrane.	
LEGS ...	Brown speckled with ochraceous, the bases of the femora distinctly ochraceous. Femora always nodulose, and slightly incrassated at the apex.	
	Length (mean)— Foreleg—Femur (including trochanter) ... 2·02 mm. Tibia ... 2·60 mm. Tarsus ... ·50 mm.	Foreleg varies from— Femur 2·17 mm. to 1·83 mm. Tibia 2·73 mm. to 2·43 mm. Tarsus ·53 mm. to ·43 mm.
	Intermediate leg— Femur (including trochanter) ... 2·01 mm. Tibia ... ... 2·55 mm. Tarsus ... ... ·50 mm.	Intermediate leg varies from— Femur 2·13 mm. to 1·83 mm. Tibia 2·70 mm. to 2·33 mm. Tarsus ·53 mm. to ·43 mm.
	Hind leg— Femur (including trochanter) ... 24·7 mm. Tibia ... ... 3·15 mm. Tarsus ... ... ·51 mm.	Hind leg varies from— Femur 2·83 mm. to 1·93 mm. Tibia 3·40 mm. to 3·00 mm. Tarsus ·63 mm. to ·43 mm.
THORAX ...	Black, with a marked longitudinal furrow down centre as far back as intermediate coxæ. Coxæ always luteous.	Colour varies from a black suffusion on an ochraceous ground to completely black.
ABDOMEN ..	Underside—luteous, ochraceous or green, with a basal spot, and the apex black.	Colour varies extremely. Basal spot sometimes missing. Apex sometimes ochraceous.
	Upper side—Apex black and hairy and decreasing black patches on the next four segments. Colour of remainder same as the underside.	Apex sometimes ochraceous. Number of segments with black patches varies from five to none.

V.—INDIVIDUAL AND SEASONAL VARIATION OF THE FEMALE.

Head.—In typical samples the head is similar in shape to that of the male already described, and possesses a similar longitudinal sulcation. There is also present a tubercle at the base of each antenna. The colour is black with variable amount of ochraceous, the black occasionally only amounting to a slight suffusion. There is often a patch of ochraceous behind the origin of each antenna, and usually a larger or smaller lateral ochraceous fascia.

Antennæ.—These are very similar to those in the male in character and colouring, but differ by having the first joint slightly mottled, and by being much less hairy and much more delicate. While the first joint is longer than in the male, the second and third are considerably shorter. The third joint is slightly shorter than the second. The greater delicacy of the antennæ is shown by the fact that our catchers rarely bring in samples with more than two joints, the third and fourth being broken off very easily. I have never received a single sample caught in the open with the four joints complete.

The colour variations of the antennæ are slight, but the changes in size, according to season, are even more marked than in the male, while the variations among individuals are also very great. As before, I will take the joints of the antennæ separately, and tabulate the results which I have obtained.

(a) First joint of the Antenna.

Month.	Longest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January ...	2·50	1·83	2·12
February ...	2·33	2·07	2·21
March ...	2·66	2·13	2·33 & 2·36
April ...	2·93	2·23	2·68
May ...	2·83	2·40	2·61
June ..	2·80	2·40	2·60
July ...	2·87	2·37	2·60
August ...	2·77	2·47	2·65
September ...	2 83	2·30	2·60
October ...	2·70	2·40	2·58
November ...	2·77	2·23	2·54
December ...	2·70	2·20	2·42

(*b*) *Second joint of the Antenna.*

Month.	Longest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January ...	4·03	3·17	3·63
February ...	3·97	3·43	3·68
March ..	4·50	3·60	3·90 & 3·86
April ...	4·66	3·53	4·29
May ...	4·70	3·93	4·28
June ...	5·53	3·97	4·38
July ...	5·13	3·93	4·26
August ...	4·50	4·07	4·31
September ...	4·63	3·93	4·28
October ..	4·60	3·83	4·35
November ...	4·50	3·77	4·18
December ...	4·40	3·63	3·99

(*c*) *Third joint of the Antenna.*—(In the months omitted, no insects examined had the third joint intact.)

Month.	Longest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January ...	3·77	3·07	3·44
February ...	...	...	3·40
March ...	3·93	3·30	3·63
April ...	4·27	3·23	3·91
May ...	4·07	3·88	3·98
June ...	4·27	4·10	4·17
July ...	4·10	3·70	3·91
September ...	4·43	3·60	4·03
October ..	4·33	4·23	4·28
November ...	...	...	...
December ..	3·73	3·57	3·66

As has already been stated, the fourth joint was not examined in any of the cases.

The variations in each of these months can be best indicated by the amount the extreme insects are above and below the mean. This is shown in the following table :—

	First Joint.		Second Joint.		Third Joint.	
	Longest. Percentage above mean.	Shortest. Percentage below mean.	Longest. Percentage above mean.	Shortest. Percentage below mean.	Longest. Percentage above mean.	Shortest. Percentage below mean.
	%	%	%	%	%	%
January ...	18·0	12·7	11·0	12·7	9·6	10·8
February ..	5·4	6·4	7·8	6·8	...	...
March ..	12·7	9·7	15·4	7·7	8·3	9·2
April	9·3	24·1	8·6	17·7	9·3	17·4
May	8·5	8·1	9·8	8·1	2·2	2·5
June	7·7	7·7	26·1	9·3	2·4	1·7
July	10·4	8·8	20·2	7·7	4·9	5·4
August ...	4·5	6·8	4·4	5·6	.	...
September ...	8·8	11·5	8·1	8·1	10·0	10 7
October ...	4·6	7·0	5·7	12·0	1·2	1·2
November ...	9·0	12·2	7·7	9·8	...	...
December ...	11·6	9·1	10·3	9·0	1·9	2·5

In critically examining the figures, of which these are a summary, there are some points which come out with considerable clearness. The first of these is the extreme irregularity of the figures. In June and July, in particular, some altogether abnormally large antennæ were found. In each case the figures were, however, carefully checked, and they only serve to show to what extent individuals may vary even at the same time of year. It cannot be said that any greater regularity is manifested at the height of the season than in the cold weather. Nor can it be that the irregularities may be explained by the presence of two species. Were this latter the case, there would be present two points in each set where a maximum number of samples would occur, but this is rarely found. Taking two typical months for the first and second joints out of the samples specified in each case, there were the following number at each point :—

First Joint.			Second Joint.		
Length in millimetres.	February (25 samples).	July (22 samples).	Length in millimetres.	February (25 samples).	July (22 samples).
2·00—2·09 ...	1	...	3·40—3·49 ...	2	...
2·10—2·19 ...	8	...	3·50—3·59 ...	6	...
2·20—2·29 ...	9	...	3·60—3·69 ...	7	...
2·30—2·39 ...	7	1	3·70—3·79 ...	3	...
2·40—2·49 ...	...	3	3·80—3·89 ..	4	...
2·50—2·59 ...	...	5	3·90—3·99 ...	3	1
2·60—2·69 ...	.	9	4·00—4·09 ..	..	5
2·70—2·79 ...	...	2	4·10—4·19 ...	...	2
2·80—2·89 ...	..	2	4·20—4·29 ...	...	7
			4·30—4·39 ..	...	2
			4·40—4·49 ...	...	3
			4·50—4·59 ...	...	0
			4·60—4·69 ...	...	1
			.....	...	...
			5·13 ...	...	1

There is, therefore, no sign of a mixture of two species in either case, and if the whole of the months are similarly treated, it is found that in no case can the presence of a double maximum (suggesting the probability of admixture of species) be certainly noticed.

The seasonal variation is great, but quite regular. The months from April to December give, in the average, extremely constant measurements. During this time the insects may be said to be flourishing and hence in a normal condition. In January,

February and March they are much smaller, and, though quite active and regularly feeding on the tea when a chance is afforded, are, relatively speaking, in a more or less resting condition. The minimum size is reached in January. The maximum, minimum, and mean length for each joint during the whole season is approximately as follows. The mean length of similar parts of the male antennæ are added for comparison :—

	Female.			Male.
	Maximum.	Minimum.	Mean.	Mean.
	mm.	mm.		mm.
First joint ...	2·87	1·83	2·50	2·43
Second joint ...	5·53	3·17	4·14	4·48
Third joint ...	4·43	3·07	3·50	4·60

Rostrum.—The rostrum is almost exactly similar to the same organ in the male, but is in all cases a little longer. It is coloured obscure ochraceous with a dark brown tip. The whole is sparsely scattered with hairs, except the tip which is quite hairy. The average length of the organ and its joints is as follows :—

Length of rostrum	1·89	mm.
„ basal joint (by difference)	·43	„
„ second joint	·42	„
„ third joint	·43	„
„ tip joint	·62	„

These figures for the separate joints are only averages for eight months, but it may be said that the three first joints are equal in length, while the tip joint is considerably longer.

As with the male, the rostrum forms one of the most constant parts of the body both in colouring and size. The following table shows the extreme variations and the mean values for the length of the whole rostrum during the year :—

Month.	Largest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January	1·90	1·63	1·78
Februar	1·90	1·73	1·81
March	1·97	1·83	1·89
April	1·97	1·73	1·89
May	2·03	1·70	1·89
June	2·03	1·80	1·92
July	2·03	1·67	1·96
August	2·03	1·83	1·95
September	1·97	1·70	1·90
October	2·03	1·83	1·92
November	1·93	1·83	1·90
December	1·97	1·73	1·88

According to this, the individual variation seems to be considerably greater than that due to season. But even among individuals the large majority lie between the limits of error in measurement.

Pronotum.—Seeing that the colour characters of the pronotum in the female have been relied on in the differentiation of species of *Helopeltis* almost more than any other character (save perhaps the scutellar horn), the study of the differences which occur have a special importance. Distant describes it as "bright shining stramineous or ochraceous, with a sub-apical transverse fascia and the basal area shining black," and this is probably an excellent description of the most common colour arrangement. The shade of ochraceous varies extremely, however, and we have seen every shade from reddish ochraceous to a very light straw colour. The amount of black on this part of the body varies extremely. As in the case of the male, I will first discuss the colouring of the 'collar'* and then that of the remainder.

The colouring of the collar was only observed for a series of samples in February, August and October.

(*a*) In February, out of eight samples, two had the collar completely ochraceous; in five cases there were one or more black spots on an otherwise ochraceous collar, and in the remaining instance the whole of the posterior half was black.

(*b*) In August, out of twenty-five samples, five had the collar entirely ochraceous; in nineteen cases the posterior portion (from one-third to one-half) was black, the remainder being ochraceous, while in one case the whole was black, save for a narrow ochraceous line in the middle.

(*c*) In October, out of twenty-five samples, two had the collar entirely ochraceous; in twenty-one cases the posterior portion was black, while in the remaining two cases there were a few black spots on an ochraceous collar.

(*d*) In November, out of twenty-two samples, eight had the collar entirely ochraceous: in nine cases the posterior portion

* For the meaning in which I use this term see page 289.

was black, while in the remaining five there were a few black spots on an ochraceous collar.

(*e*) In December, out of twenty samples, ten had the collar entirely ochraceous; in five cases the posterior portion was black or at least dark, while in the remaining five there were a few black spots on the ochraceous collar.

Apparently, the typical form has a transverse black fascia, taking up most of the posterior half of the collar, but, as will be seen, the variations are considerable.

The remainder of the pronotum is even more variable in its colour markings. Typically the pronotum may be described as by Waterhouse as being "orange yellow, with a black line near the front margin, the base margined with black." The following observations show to what an extent the amount of black on the pronotum varies.

(*a*) In February, out of twenty-five samples, seven agree with the type described by Waterhouse, in that there is only a narrow marginal patch of black on the posterior of the pronotum. In eighteen cases this posterior black patch spread, in the centre, from one to two-thirds of the length of the pronotum.

(*b*) In August, out of twenty-five samples, twenty-one were typical; three had the black patch from one-third to two-thirds the length; while one sample had no black whatever on the pronotum, simply a slight dark suffusion on the posterior margin.

(*c*) In October, out of twenty-five samples, twenty-three were typical; in one case the black patch was nearly half way to the front of the pronotum, while in the other case the whole was suffused with black throughout.

(*d*) In November, out of twenty-two samples, twelve were typical: in the remaining ten instances the posterior black patch extended over one-third or more of the length of the pronotum.

(*e*) In December, out of twenty samples, eleven were typical; in the remaining nine cases, the posterior black patch extended over one-third or more of the length of the pronotum.

These details suffice to show what has been many times observed, how different is the appearance of the pronotum on the insects gathered in the cold weather and in the height of the season. In fact, the darker, blacker character of the pronotum in the former part of the year, is the first point which strikes the observer who undertakes a study of the seasonal variations of the insect.

We come, in fact, to the conclusion that there is a very great increase in contrast between males and females in the height of the season; the former become darker and the latter become more ochraceous. This is shown by the samples received from the tea estates. In the months from June to December, it is rare that a mistake in classifying the insects as male or female occurs, while during December, January and February in particular, many males are placed along with the female insects.

Head and Pronotum.—The combined length of the head and pronotum has been stated to be about equal in length to the first joint of the antenna. This is not the case, for while the average length of the latter is 2·50 mm., the length of the head and pronotum measured out as follows :—

February	...	... 1·63 mm.
August	...	... 1·73 mm.
September	...	... 1·73 mm.
October	...	... 1·73 mm.
November	...	... 1·73 mm.
December	...	... 1·57 mm.

Scutellum.—The scutellum is usually ochraceous, with a darker shade than the pronotum, or as Distant expresses it "ochraceous, more or less suffused with black." I have not been able to examine in detail the divergences from this typical colour. The scutellar horn is, however, as with the male, a point of considerable interest. Distant describes it as "long, black, piceous at apex, and also as more or less distinctly curved backward." With regard to the bending, it may at once be said that it is almost always very much more curved than the horn of the male. While in many of the latter sex, it is difficult to detect any bending at all, in the female the curve is nearly always very

distinct, but the amount of bending is very variable. As with the male, I have attempted to classify the amount of bending, and the following table shows the percentage of "slightly bent," "moderately bent," and "very bent" horns in the catches for several months:—

Month.	Scutellar Horn.		
	Slightly or very slightly bent.	Moderately bent.	Very bent.
	Per cent.	Per cent.	Per cent.
January ...	15	58	27
February ..	12	50	38
March ..	26	42	32
August ...	4	83	13
September ...	21	38	41
October ..	5	71	24

I do not attribute any very great accuracy to the determination of the amount of bending, as the above were noted in at different times, extending over a period of nearly six months, but they suffice to indicate the extreme variability of the backward curve in the scutellar horn.

The colour is equally variable, and the form described as typical by Waterhouse does not occur at all commonly. In fact, one may say that most frequently the horn has an ochraceous ring round the centre and a tip ochraceous to luteous in colour. The following cases illustrate the variations.

(*a*) In February, out of eighteen insects, eleven were as just described; four were completely black, except for a luteous tip; one was black throughout, while two were ochraceous, except for quite narrow rings of black at the base and just under the knob.

(*b*) In August, out of twenty-three insects, sixteen were as described above. In five cases there was only a narrow ring of black at the base and under the tip; in one case all was black, except the tip, and in one case also there was an ochraceous ring, but the tip itself was black.

(*c*) In October, out of twenty-two, nineteen were as described above; one was, except for a narrow patch at the bottom

and under the knob, completely ochraceous; one was black entirely, except for an ochraceous tip, and one had an ochraceous ring, but the tip was black.

It is, therefore, very evident that the colouring of the scutellar horn varies enormously, but on the whole is very similar to that of the same organ in the male.

The length of the scutellar horn has only been determined in a few cases, and the results are not very reliable. The averages for April, May, June and July are respectively 1·39 mm., 1·40 mm., 1·61 mm., 1·55 mm., showing that the horn, in common with the other parts of the body, increases in size during the season most favourable to the development of the insect.

These results are quite sufficient to show that the scutellar horn, owing to its extremely variable character, is quite unsuitable as a determining factor in classifying the species of *Helopeltis*, and that this applies equally to that of the female and to that of the male.

Wings.—The description of the wings already given under the male applies almost equally to those of the female, and therefore need not be repeated. They are, however, larger in the female, and measurements have been made of the hemelytron at all seasons.

The maximum length of the hemelytron and of the corium of the same individual came out as follows :—

Month.	Maximum length of forewing.	Length of corium.
	mm.	mm.
January ...	5·07	3·10
February ..	5·36	3·33
March ...	5·23	3·20
August ...	5·13	3·20
September ...	5·60	3·37
October .	5·33	3·20
November ..	5·47	3·20
December ...	5·27	3·07

These are only, however, the measurements of individual samples, and hence have no value as indicating the mean for their months.

The average length of the corium in the several months was as follows :—

Month.	Longest specimen.	Shortest specimen.	General average.
	mm.	mm.	mm.
January	3·40	2·87	3·11
February	3·40	2·87	3·19
March	3·40	3·10	3·28 & 3·26
April	3·50	3·06	3·32
May	3·50	3·07	3·31
June	3·43	3·07	3·27
July	3·50	3·00	3·26
August	3·33	2·97	3·23
September	3·40	2·93	3·21
October	3·43	2·97	3·24
November	3·50	3·10	3·25
December	3·37	2·93	3·19

These results are very constant. The monthly means do not vary more than $6\frac{3}{4}$ per cent. Individuals vary considerably more than this and, hence, as with the male, we have to do more with an individual than a seasonal variation. The differences between the largest and smallest wings in January and February is greater than in any other month, indicating, as remarked with the male, that the colder weather and the then condition of life has a tendency to destroy uniformity.

The relative length of the corium and cuneus has been determined also for all samples for three months (August, November and December). The figures gave (mean) 3·22 mm. for the corium and 1·33 mm. for the cuneus, or a relationship of slightly less than $2\frac{1}{2}$ to 1.

Legs.—No better description of the legs of the female can be given than that of Distant :—" Femora dark brown, mottled with ochraceous, and with a distinct pale annulation near base ; tibiæ ochraceous, speckled with fuscous." The three legs are extremely similar in form and colouring, and as with the male, the fore and intermediate legs are approximately the same size and smaller than the hind leg. The colouring is very constant. The femora are distinctly nodulose and slightly incrassated at the apex. The trochanter has been measured with the femur. The tibia is very hairy at the lower part, and the structure of the tarsus precisely similar to that of the male.

I have, in many months, measured in individual insects, the fore, intermediate and hind legs, and the following are the figures thus obtained :—

Month.	Fore Leg.			Intermediate Leg.			Hind Leg.		
	Femur.	Tibia.	Tarsus.	Femur.	Tibia.	Tarsus.	Femur.	Tibia.	Tarsus.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
January	1·77	2·33	·43	1·73	2·27	·47	2·20	2·90	·47
February ...	1·93	2·57	·50	1·87	2·50	·50	2·37	3·13	·53
March ...	1·93	2·47	·47	1·97	2·43	·47	2·40	3·03	·50
August ...	2·10	2·73	·53	2·10	2·73	·53	2·63	3·43	·57
September ...	2·20	2·90	·50	2·20	2·80	·50	2·53	3·67	·57
October ...	2·10	2·77	·53	2·10	2·77	·53	2·57	3·43	·57
November ...	2·00	2·63	·47	2·00	2·63	·47	2·53	3·33	·50
December ...	2·07	2·77	·47	2·07	2·73	·47	2·57	3·43	·50

All the legs therefore share the seasonal reduction in size which takes place in the early months of the year, and which reaches its extreme in January. This is more completely indicated by the following larger series of observations on the hind leg :—

Month.	Length of Femora.			Length of Tibia.			Length of Tarsus.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
January ...	2·60	2·10	2·33	3·33	2·77	3·07	·53	·43	·49
February ..	2·50	2·10	2·37	3·37	2·77	3·09	·53	·47	·50
March ...	2·63	2·30	2·50	3·43	2·97	3·24	·57	·43	·51
April ...	2·80	2·40	2·69	3·70	3·07	3·49	·56	·50	·51
May ...	2·87	2·57	2·73	3·77	3·30	3·52	·57	·50	·53
June ...	2·90	2·53	2·72	3·83	3·27	3·53	·60	·53	·55
July ...	2·93	2·53	2·73	3·77	3·33	3·51	·57	·53	·54
August ...	2·87	2·43	2·71	3·70	3·27	3·50	·57	·53	·56
September	2·77	2·43	2·62	3·67	3·20	3·44	·57	·50	·54
October ...	2·83	2·33	2·66	3·70	2·87	3·47	·60	·50	·55
November ...	2·83	2·43	2·57	3·70	2·90	3·35	·53	·50	·51
December ...	2·67	2·33	2·52	3·53	3·13	3·30	·57	·47	·51

These figures indicate that the extremes of individual variation are—

(1) for the femora—2·93 mm. to 2·10 mm. or sixteen per cent above or below the mean.

(2) for the tibiæ—3·83 mm. to 2·77 mm. or over sixteen per cent above or below the mean.

(3) for the tarsus—·60 mm. to ·43 mm. or nearly seventeen per cent above or below the mean.

The seasonal variation of the mean is also very great. From sizes of 2·33 mm., 2·77 mm , and ·49 mm. for the femur, tibia and tarsus respectively in January, a rise occurs to 2·72 mm., 3·53 mm., and ·55 mm. respectively in June. One may note the curious fact that apparently the female both reaches the minimum and maximum sizes earlier in the season than the male. The figures are however very constant from April till October.

Thorax.—My observations on the thorax indicate that it is generally wholly ochraceous with the slightest suffusion of black in places. There is, as with the male, a marked furrow from the anterior margin to the intermediate coxæ ; in fact, just as far as the rostrum extends in life. The coxæ are always luteous.

Abdomen.—The abdomen varies from ochraceous to almost luteous in colour, the prevailing tint being a light green. This is, however, marked with dark brown on several segments both on the upper and under side.

The underside bears a corneous ovipositor arising from the sixth abdominal segment, as described by Dudgeon, and extends to the final segment of the abdomen. The section from which it arises and the two following ones, as well as the apex, are usually dark-brown or black. This is by no means invariably the case, and in breeding these insects I fell upon the reason for the differences. Immediately after the last moult, I found that the females were ochraceous throughout, without a trace of black or dark-brown anywhere on the body except the eyes. This condition of things lasted a few hours only, and gradually the more normal colour was developed. Under these conditions even the ovipositor was ochraceous. It is evident, therefore, that unless one knows the age of a sample from the final moult, the amount of black on the insect has no value as a means of determining species. Since one can never tell the age of the insect in caught samples, it follows that the description of the spotting with dark-brown or black in any particular samples is almost if not quite useless.

This applies to the whole of the insect, including the abdomen, but as I have made careful notes of the amount of black on the upper side of the abdomen in a large number of cases, it may be

worth while to record them. Typically the tip is black, and two more segments, and there are black spots decreasing in size on the next two segments. The posterior margins of the black segments are often, but not always, narrowly ochraceous or green. To show to what extent individuals vary, the observations for August and October may be detailed.

(*a*) In August, out of twenty-four insects, eight had the typical characters just described, eight had black patches on five segments beside the tip, and one had black markings only on three sections. The remainder (seven) had no black anywhere, both abdomen and tip being ochraceous or greenish in colour.

(*b*) In October, out of twenty-two insects, eight had typical characters, six had black on five segments beside the tip, three with black on three segments, two with black on two segments, and one with no black on any section. Two were quite irregularly spotted.

(*c*) In November, out of twenty-two insects, nine were typical, seven had black on five segments beside the tip, while the remainder had no black anywhere.

(*d*) In December, among twenty samples examined, nine were typical, two had black on five segments beside the tip, and one had black on only three segments. Four were entirely ochraceous, and the remainder had a slight dark suffusion on the tip and four segments.

We may perhaps now draw up a description of the female of *Helopeltis theivora* as occurring in Assam and feeding on tea similar to that already given for the male, and show the extent of the variations which may occur :

Part of Insect.	Typical characters.	Extent of variation.
HEAD ...	Shape as with male. Antennæ inserted as with male. Minute tubercle just inside insertion of antennæ. Colour—indefinite mixture of brownish ochraceous and black, under sides generally lighter than above. Luteous fascia on each side of head.	Colour varies from wholly ochraceous (except eyes) to almost completely black.

Part of Insect.	Typical Characters.	Extent of Variation.
ANTENNÆ ...	Four jointed. Second, third, and fourth (?) joints much less hairy than male.	Hairiness very variable.
	First joint—brown, somewhat mottled, yellowish at base and (as a mean) 2·50 mm. long. Slightly incrassated at apex.	Length varies from 2·93 mm. (April) to 1·83 mm. (January).
	Second joint—brownish black, shining, thinner than base joint, and 4·14 mm. long (mean).	Length varies from 5·53 mm. (June) to 3·17 mm. (January).
	Third joint—similar to second, but slightly thinner. Length (mean)—3·47 mm.	Length varies from 4·43 mm. (September) to 3·07 mm. (January).
	Fourth joint—not observed.	
ROSTRUM .	Colouring and shape as with male. In life reaches to intermediate coxæ.	
	Average length— Whole rostrum .. 1·89 mm. Second joint ... ·41 mm. Third ,, ... ·43 mm, Tip ,, ... ·62 mm,	Length of rostrum varies from 2·03 mm. to 1·63 mm.
PRONOTUM ..	Shape as in male.	
	Collar has transverse ochraceous fascia on posterior half.	Varies from completely ochraceous to having the whole of the posterior half black.
	Remainder of pronotum ochraceous with the base margined with black.	The tint of the ochraceous portion is very variable, from reddish ochraceous to light stramineous. The amount of black varies from nothing to a posterior patch more than half covering this section of pronotum.
HEAD AND PRONOTUM.	Combined length—1·75 mm. ...	Varies at least from 1·87 mm. to 1·57 mm.
SCUTELLUM ...	Ochraceous, darker than pronotum.	
SCUTELLAR HORN.	Black with ochraceous ring round middle and ochraceous to luteous tip.	Colour varies from entirely black, to ochraceous with black ring at base and under tip, and luteous tip.
	Tip spherical and very hairy.	
	Bent backwards, usually more than with male.	Bending very variable.
	Length—1·48 mm. mean ...	Length varies from 1·61 mm. to 1·39 mm.
WINGS, HEMELYTRON.	Shape, colouring and characters as in male.	
	Corium length—3·24 mm. (mean)	Corium varies from 3·50 mm. to 2·87 mm.
	Cuneus length—1·33 mm. (mean).	
	Maximum length—5·3 mm. (mean) ...	Maximum length varies from 5·60 mm. to 5·13 mm.
	(The figure for the cuneus is for three months only—August, November and December).	
HINDWING ...	As with male, but slightly larger.	

Part of Insect.	Typical characters.	Extent of variation.
LEGS ...	Colouring and shape as in male.	
	Length (mean)—	Foreleg varies from—
	Foreleg—	
	Femur (with trochanter) 2·00 mm.	Femur ... 2·17 mm. to 1·77 mm.
	Tibia ... ... 2·63 ,,	Tibia ... 2·90 ,, to 2·33 ,,
	Tarsus ... ... ·49 ,,	Tarsus ... ·53 ,, to ·43 ,,
	Intermediate leg—	Intermediate leg varies from—
	Femur (with trochanter) 2·00 mm.	Femur ... 2·20 mm. to 1·73 mm.
	Tibia ... .. 2·58 ,,	Tibia .. 2·80 ,, to 2·27 ,,
	Tarsus ... ... ·50 ,,	Tarsus ... ·53 ,, to ·47 ,,
	Hind leg—	Hind leg varies from—
	Femur (with trochanter) 2·61 mm.	Femur ... 2·93 mm. to 2·10 mm.
	Tibia ... ... 3·39 ,,	Tibia ... 3·83 ,, to 2·77 ,,
	Tarsus ... ... ·53 ,,	Tarsus ... ·53 ,, to ·43 ,,
THORAX ...	Ochraceous, with slight suffusion of black in places.	
	Marked furrow from anterior margin to intermediate coxæ.	
	Coxæ luteous.	
ABDOMEN ..	Underside luteous ochraceous or green, with apex and three adjoining segments black.	Apex and all the remaining segments may be the same colour as the rest of the abdomen.
	From the sixth abdominal segment rises the ovipositor.	
	Ovipositor is corneous, and extends to the terminal segment; usually black.	Ovipositor sometimes ochraceous.
	It is double, and thus two eggs are usually laid at once. Edges of tip of ovipositor serrated. Length 1·5 mm. (approx.).	
	Upper side.—Apex black, next two segments black, and then decreasing black patches and next two segments. Colour of remainder as with the underside.	The colouring of the abdomen is very variable.
	Anus—about ·3 mm. in diameter.	

VI.—VARIATIONS DUE TO LOCALITY.

We have so far considered the variations which are induced by casual circumstances leading to alteration in the morphological characteristics of the *Helopeltis theivora*, and also the variations induced by changes of season. There remain two further circumstances which may lead to variation, namely, change of locality and change of food. I have been able to investigate both of these points to a small and insufficient extent, but the data so far obtained have a certain value, and as it will probably not be possible to continue the detailed study, they may be cited here.

With regard to the effect of locality, I have been able to collect samples of *Helopeltis* insects from Assam (already described); the lower part of the Darjeeling district (Singla), at an elevation of from 1,200 to 3,000 feet; from Koomber, Cachar, at an elevation of under 150 feet; and from Ellenbarrie in the Duars, at about five hundred feet above the sea. They have only been obtained for a month in each case at the height of the season, but the mean figures for the months at this time of the year have proved so constant in the former cases that it seems to matter little, whether the insects be taken in August, September, or October. I will give here the mean figures for my measurements in each case, and only call attention to any point if it is beyond the range of variation already laid down :—

Males.

Length of parts of Insect.	Behalli, September.	Singla, September.	Koomber.	Ellenbarrie, September.
(MEAN FIGURES.)				
Antenna—	mm.	mm.	mm.	mm.
1st joint	2·53	2·56	2·45	2·48
2nd ,, ...	4·60	4·91	4·44	4·47
3rd ,, ...	4·76	4·59	4·59	4·58
Forewing, length of Corium	2·78	2·95	2·77	2·78
Rostrum	1·76	1·85	1·92	1·76

Males.—(Contd.)

Length of parts of Insect.	Behalli, September.	Singla, September.	Koomber.	Ellenbarrie, September.
(MEAN FIGURES.)				
Hind Leg—	mm.	mm.	mm.	mm.
Femur	2·55	2·59	...	2·53
Tibia	3·21	3·27	.....	3·16
Tarsus	·54	·52	.....	·51
Scutellar Horn	.....	1·45	.....	1·37*
(INDIVIDUAL.)				
Head and Pronotum	1·57	1·63	.....	1·47
Forewing, maximum length	4·60	5·04	4·40	4·73
Foreleg—				
Femur	2·17	2·17	.....	2·10
Tibia	2·70	2·90	.....	2·63
Tarsus	·50	·53	.....	·50
Intermediate leg—				
Femur	2·13	2·17	.....	2·10
Tibia	2·70	2·90	.....	2·63
Tarsus	·50	·53	.....	·50

Among these there are only a very few measurements which call for note. The limits of variation in nearly every case are well within those laid down already for the insects, though not necessarily within the limits previously obtained for the same month. One strange figure, however, calls for notice. In one case at Singla, the second joint of the antenna reached the huge length of 6·33 mm.,—the highest for the whole season obtained at Behalli being only 5·57 mm. No explanation can be attempted and the remainder of the insects were well within the previously observed limits.

Females.

Length of parts of Insect.	Behalli, September.	Singla, September.	Koomber.	Ellenbarrie.
(MEAN FIGURES.)				
Antenna—	mm.	mm.	mm.	mm.
1st joint	2·60	2·33	2·54	2·60
2nd joint	4·28	3·90	4·23	4·23
3rd joint	4·03	3·63	.....	4·00
Forewing, length of Corium	3·21	3·28	3·24	3·24
Rostrum	1·90	1·89	1·90	1·92
Hind Leg—				
Femur	2·62	2·50	2·78	2·73
Tibia	3·44	3·24	3·52	3·49
Tarsus	·54	·51	·57	·53
Scutellar horn	.....	.....	1·43	1·53*
(INDIVIDUAL.)				
Head and Pronotum	1·87	.....	1·63	1·67
Forewing, maximum length	5·60	5·23	5·27	5·33
Foreleg—				
Femur	2·20	1·93	2·23	2·17
Tibia	2·90	2·47	2·90	2·60
Tarsus	·50	·47	·53	·50
Intermediate leg—				
Femur	2·20	1·97	2·23	2·13
Tibia	2·80	2·43	2·90	2·60
Tarsus	·50	·47	·53	·47

* Individual only.

Among these females it will at once be noticed that the Singla insects, being from a higher elevation, are smaller than the others, but are still well within the limits of variation for the species as found in Assam.

The colouring was almost if not quite similar in the different localities. If anything, those from the higher elevations at Singla were more ochraceous (especially in the abdomen) and less green than those in the plains, but it is certainly not possible to speak confidently on the point. And if collecting the insects attacking tea at widely separated points in the tea districts of North-East India be a guarantee of obtaining every type of insect, it may be said with confidence that there is now only one species of Helopeltis attacking tea in this area.

This point is of considerable interest because Watt, in a very interesting and productive tour, which he made in Assam in 1895, found two insects attacking tea which he called the 'red tea mosquito' and the 'green tea mosquito.' The former was principally found on the south bank of the Brahmaputra; the latter on the north. I have never been able to get an authentic specimen of these two supposed species, but in view of the figures given and of the gradations of colour which are seen to occur in every garden when close study is given to the question, one would be inclined to fancy that the differences noted by Watt were within the range of variation which we have noted on the same place, if he had not found also differences in hairiness, and it is a great pity that his specimens have disappeared, as my search during several years for the orange red type that he describes in Assam has been quite futile.

VII.—VARIATIONS DUE TO CHANGE OF FOOD.

There only remains the variation caused by change of food to be dealt with. And here I am sorry to say that my observations are limited to some samples supplied by Mr. R. Pantlung, Superintendent of the Government Cinchona Plantations, Bengal, caught feeding on Cinchona. The figures obtained for these and the notes made on them are, however, of some interest, though I had hoped to have had samples also from Cacao. The figures are as follows, compared with those obtained for tea at Behalli for the same month.

Males.

Length of parts of Insect.	Tea.	Cinchona.	
	Behalli October.	Mungpoo A.	Mungpoo B.
	mm.	mm.	mm.
(Average.)			
Antenna—			
1st joint	2·51	2·56	2·47
2nd joint	4·59	4·60	4·48
Rostrum	1·76	1·75	1·72
Forewing—			
Corium	2·79	2·85	2·83
Cuneus	.....	1·19	1·12
Hind leg—			
Femur	2·51	2·57	2·52
Tibia	3·14	3·21	3·16
Tarsus	·54	·50	·51
(Individual.)			
Foreleg—			
Femur	2·05	2·20	2·10
Tibia	2·67	2·73	2·67
Tarsus	·50	·53	·50
Intermediate leg—			
Femur	2·05	2·17	2·03
Tibia	2·53	2·63	2·67
Tarsus	·50	·50	·50
Forewing, maximum length	4·73	4·73	4·90
Scutellar horn	1·37 (mean)	1·40	1·27

Females.

Length of parts of Insect.	Tea.	Cinchona.	
	Behalli October.	Mungpoo A 2,700 ft.	Mungpoo B 4,000 ft.
(Average.)			
Antenna—	mm.	mm.	mm.
1st joint	2·58	2·65	2·60
2nd joint	4·35	4·30	4·32
Rostrum	1·92	1·95	1·96
Forewing—			
Corium	3·24	3·39	3·33
Cuneus	.....	1·43	1·38
Hind leg—			
Femur	2·66	2·75	2·72
Tibia	3·47	3·52	3·53
Tarsus	·55	·53	·55
(Individual.)			
Foreleg—			
Femur	2·10	2·23	2·20
Tibia	2·77	2·87	2·63
Tarsus	·53	.....	·53
Intermediate leg—			
Femur	2·10	2·23	2·27
Tibia	2·77	2·83	2·87
Tarsus	·53	.....	·53
Forewing Maximum length	5·33	5·84	5·43

These figures call for no remark. The change of food from tea to cinchona seems to have led to no modification in the structure of the *Helopeltis* insects, and their colouring remains the same as it was before. The differences in the above figures are well within the limit of variation already determined for the insect as it occurs on tea.

VIII.—RELATIONSHIP BETWEEN HELOPELTIS THEIVORA AND HELOPELTIS ANTONII.

During the course of the present investigation, Mr. E. E. Green, the Government Entomologist of Ceylon, very kindly supplied me with samples of *Helopeltis antonii* found on both tea and cacao in that island. It is, of course, well known that the place of the *H theivora* of India as a pest of tea is taken by *H. antonii* in Ceylon, and it was interesting to ascertain what were the differences between the two insects, and which of these were constant.

The Ceylon insect is thus described by Distant.

"*Helopeltis antonii.*

"*Male.*—Head and pronotum black, anterior margin of pronotum narrowly obscurely ochraceous; rostrum obscure ochraceous, more or less suffused with fuscous, prominently so at apex; antennæ shining piceous, ochraceous at base; scutellum black, testaceous at apex; hemelytra pale, olivaceous fuscous; legs brown, speckled with ochraceous; bases of femora distinctly ochraceous; abdomen beneath luteous with a basal spot and the apex black; scutellar horn nearly straight and perpendicular.

"*Female.*—Pronotum, and most of the scutellum purplish red, the transverse constriction to the first sometimes piceous.

"Length, 6 to 7½ millim."

It is evident that almost all this description, with the exception of the purplish red character of the female pronotum, and the straight character of the scutellar horn (and both of these I have already shown to be variable characters), might almost equally well apply to *H. theivora*, and it became of great interest to determine where the difference really lay, if such difference really existed. After my examination there remains, no doubt,

whatever of the distinctness of the two species, but the points of real difference are entirely missed in the above description. The diagram of the scutellar horn, which accompanies it, is also quite unnatural.

Before going on to consider the differences between the Indian and the Ceylon insects, I may note that the latter are very similar, whether from cocoa in November 1906, or from tea in February 1907, the differences being well within the range already given for the seasonal variations of *H. theivora*. To take a series of typical measurements (in each case except those in brackets), the average of a number, we have as follows :—

Length of	February 1907. (From Tea.)		November 1906. (From Cocoa.)	
	Male.	Female.	Male.	Female.
	mm.	mm.	mm.	mm.
Antenna—				
1st joint	2·27	2·45	2·20	2·31
2nd joint	4·14	4·16	4·19	4·24
3rd joint	(3·43)	.....	(3·57)	2·83
Forewing—				
Corium	2·81	3·29	2·89	3·46
Cuneus	·99	1·21	1·14	1·36
Hind leg—				
Femur	2·45	2·67	2·59	2·77
Tibia	3·06	3·39	3·14	3·51
Tarsus	·52	·52	·51	·52
Rostrum	1·79	2·00	1·82	2·07

The principal points in which the Ceylon insect (*Helopeltis antonii*) differs from *Helopeltis theivora*, are as follows :—

Antenna.—In the males of the two insects the length of the several joints is as follows :—

Males.

	Helopeltis Theivora.			Helopeltis Antonii.		
	Average.	Variations.		Average.	Variations.	
	mm.	mm.	mm.	mm.	mm.	mm.
1st joint	2·40	2·83	to 1·83	2·23	2·40	to 2·07
2nd joint	4·44	5·57	to 3·57	4 17	4·43	to 3·97
3rd joint	4·56	5·10	to 3·73	.....	3·57	to 3·43
4th joint	1·53	1·70	to 1·58	.....	.....	.....

Here it will be seen that though the length of the first and second joints are not very dissimilar in the two insects, in *Helopeltis antonii*, the third joint is much shorter than the second, while it is at least equal with *H. theivora*. A similar shortness of the third joint is shown in the female :—

Females.

	H. theivora. Average.	*H. antonii.* Average.
	mm.	mm.
1st joint	2·15	2·38
2nd joint	4·14	4·19
3rd joint	3·47	2·87

In colouring of the antenna there was no obvious difference.

Rostrum.—On the whole, the rostrum appears to be slightly longer with the Ceylon insect, but the relative length of the joints is the same.

Pronotum.—The pronotum in the male, as described by Distant for *H. antonii*, might possibly apply to some of the *H. theivora* from India, but would certainly not do so for the Ceylon insect. I should describe the latter as follows :—Collar is generally ochraceous, with posterior margin black. Remainder of pronotum reddish ochraceous with anterior margin black, and slight suffusion of black over the central posterior portion.

The pronotum of the female *H. antonii* might be thus described :—Collar is generally ochraceous, but has the posterior portion black ; remainder of pronotum has anterior margin black, otherwise reddish ochraceous, with slight suffusion of black in the posterior centre.

Of course, in each case, though this description gives the typical colouring, yet, as with *H. theivora*, there are considerable variations.

Scutellar horn.

Male. Length	...	*Helopeltis theivora*	... 1·53 mm. to 1·03 mm.
		Helopeltis antonii	... 1·20 mm. to 1·13 mm.
Female. Length	...	*Helopeltis theivora*	... 1·61 mm. to 1·39 mm.
		Helopeltis antonii	... 1·47 mm. to 1·43 mm.

No difference can, therefore, be made (as imagined by Waterhouse), out of the length of the scutellar horn. As regards the amount of bending in the horn, there is little difference in the male between the two species, but much on the average, in the female. *Helopeltis theivora* (female) almost always has a very curved horn, that of *H. antonii* is hardly curved, but this is sufficiently variable to make it inadvisable to make it a primary point in classifying the species. The coloration of the scutellar horn is considerably different in all the specimens I have examined in the two species ; that of *H. theivora* has been already described. In both the male and the female of *H. antonii* the typical colour is black, with a luteous base, and a tip varying from luteous to dark ochraceous. It is, however, very variable, the whole of the organ being occasionally ochraceous in colour, with at most a very slight dark suffusion.

There is nothing either in the wings or the legs on which any differentiation can be made. The femora in *H. antonii* are usually, however, less speckled with ochraceous than in *H. theivora*, being almost a uniform dark brown colour with the exception of a broad luteous band at the base.

The colouring of the abdomen is quite different in the two insects, though how far this is a definite character in the Ceylon insect I am not sure. In the cases I have examined, the abdomen in a typical male is greenish to greenish-luteous in colour, the tip segment being black and from three to five others, the remainder having a few spots of black on them. There is also a black spot at the side of the abdomen on the two or three segments at the base. The female has a much more reddish-yellow abdomen, but the black markings on the dorsal surface are almost exactly the same ; there are, however, lateral black spots on almost every segment, decreasing in amount from the base towards the apex.

The coloration of the underside of the thorax varies extremely from ochraceous to black, and the coxæ may be either luteous or black. On the whole, I think, that the differentiation

between these species will have to depend on the following characters :—

(1) The length of the third joint of the antenna relative to the second.

(2) The colouring of the pronotum in the male.

(3) Subsidiarily on the curvature of the scutellar horn in the female.

(4) Subsidiarily, on the colouring of the abdomen.

It is a great pity that, except for the first of these, the differentiation depends on such characters as colouring and curvature, and before these points can be regarded as satisfactorily established as constant enough for the purpose, large numbers of the insect collected in every month in the year would have to be examined. The first item, however, seems quite definite as between the two species now under discussion.

IX.—NEW SPECIES OF HELOPELTIS.

In going through the samples received from the Cinchona plantation at Munsong in British Bhutan, and twenty miles from Mungpoo where those already recorded were obtained, it was found that the whole of the samples were markedly different from any that had previously been examined. The whole of the insects had a reddish ochraceous tinge, which marked them off from the ordinary form completely. One or two of these insects were afterwards found among the catch sent me from Mungpoo itself. This was at first thought to be a modification in colouring induced by changes of conditions, but on close examination, it was found that the insect was marked off completely by the structure of the antennæ. The first joint of these was very short and incrassated throughout almost the entire length : the second joint was also much shorter than usual with *Helopeltis theivora*. Further differences which then became evident were the bright red colouring of the apex and inner margin of the cuneus, quite different and characteristic markings of the pronotum, and the differently shaped and luteous character of the scutellar horn. I would not insist in the latter two points in the absence of the first, and place principal reliance in differentiating these insects from those described hitherto on the different structure of the antennæ.

The following are measurements obtained with this insect. I regret that paucity of material prevented me from dissecting and measuring more than three males and five female insects. The ordinary *Helopeltis theivora* on Cinchona is placed side by side for comparison.

Length of parts of Insect.	Male.		Female.	
	Helopeltis theivora on Cinchona.	New insect on Cinchona.	Helopeltis theivora on Cinchona.	New insect on Cinchona.
(Average.)	mm.	mm.	mm.	mm.
Antenna—				
1st joint	2·47	·97	2·60	1·13
2nd joint	4·48	3·00	4·32	3·22
3rd joint	.. ..	.....	.....	2·74
Rostrum	1·72	1·60	1·96	1·73
Forewing—				
Corium	2·83	2·90	3·33	3·50
Cuneus	1·12	1·17	1·38	1·35
Hind leg—				
Femur	2·52	2·50	2·72	2·76
Tibia	3·16	3·13	3·53	3·51
Tarsus	·51	·57	·55	·61
(Individual.)				
Fore leg—				
Femur	2·10	1·93	2·20	2·00
Tibia	2·67	2·33	2·63	2·63
Tarsus	·50	·50	·53	·57
Intermediate leg—				
Femur	2·03	2·10	2·27	2·20
Tibia	2.67	2·43	2·87	2·80
Tarsus	·50	.....	·53	·57
Forewing, maximum length	4·90	4·70	5·43	5·74
Scutellar horn	1·27	1·27	.....	1·57

In almost every point, therefore, except the antennæ, the new insect from Cinchona at Munsong is extremely close in size and proportion to *Helopeltis theivora*. Yet in this point the difference is so marked that I think we are justified in separating it from the former. At first I thought it might be the long lost *Helopeltis febriculosa* of Bergroth. The latter, however, certainly no more agrees with the new insect than does *Helopeltis theivora*, in fact less so. The following are points in the description of *H. febriculosa* (female) which do not agree :—

(1) The first joint of the antennæ extends a little beyond the apex of the scutellum. In the new insect it does not reach the posterior margin of the pronotum.

(2) "Rostrum nearly reaching beyond the last pair of feet." In the new insect it only extends to the intermediate coxæ.

(3) "Thorax.....with a transverse basal band more extended forward to middle, and transverse streak placed a little before the apex black." This would agree with some of the variations of *Helopeltis theivora*, but certainly does not agree with the new insect.

(4) "Cuneus piceous." In the new insect the cuneus both in the male and female is largely bright red in my samples.

It is evident, therefore, that the new insect is no more *Helopeltis febriculosa* than it is *Helopeltis theivora*. In fact, it agrees with no described species of *Helopeltis* that I have been able to trace, and it seems, therefore, justifiable to describe it as new. I name it, therefore, *Helopeltis* cinchonæ* and describe it as follows :—

HELOPELTIS CINCHONÆ *n. sp.*

Male.—Three samples, caught in October, examined.

Parts of Insect.	Typical characters.	Variation noticed.
HEAD ...	Shape as for the genus, black all over. No tubercle at base of antennæ.	
ANTENNÆ ...	Four-jointed. *First joint*—Stramineous—luteous speckled with black, nodulose, and incrassated during most of the length. Length—·97 mm. *Second joint*—Dark brown with black tip. Length—3·00 mm. *Third joint*—Dark brown, extreme base and apical third black, slightly thickened at apex. Length—not observed. *Fourth joint*—not observed.	
ROSTRUM ...	Four-jointed, Ochraceous-luteous, with dark brown. Tip—Length—1·60 mm. 2nd joint—·33 mm. 3rd joint—·37 mm. 4th joint—·50 mm.	
PRONOTUM ...	Shape as for genus. Wholly black above and below.	
HEAD AND PRONOTUM.	Length—1·37 mm. (?)	
SCUTELLUM ...	Black.	
SCUTELLAR HORN.	Black about a quarter of the length from the bottom. Above this is luteous throughout, except for extremely narrow ring just below the tip. As stout as with *Helopeltis theivora*. All my samples very slightly bent. Length—1·27 mm. The clavate tip is not nearly so large relatively to the thickness of the horn as with *H. theivora*.	

* I place this species in the genus *Helopeltis* because the general relations of the insect seem to bring it very close to *Helopeltis theivora*. If the relative length of the head and pronotum and the first joint of the antenna be thought to be of generic importance, it would form a new genus. I hardly think that they should be considered as such in spite of the original definition of the genus by Signoret.

Male.—Three samples, caught in October, examined—(*contd.*)

Parts of Insect.	Typical characters.	Variation noticed.
WINGS, HEMELYTRON.	As in *H. theivora*, but slight suffusion of black throughout. Cuneus has apex and inner portion bright red, extending sometimes into the vein in the membrane. Corium—Length—2·90 mm. Cuneus—Length—1·17 mm. Maximum length—4·70 mm.	
HINDWING ...	Extremely like *H. theivora*. One additional diagonal vein, separated, in the inner portion of membrane.	
LEGS ...	*Hind leg*—Dark femur, with light coloured ring at base, and with variable quantities of reddish ochraceous. Tibia and tarsus ochraceous, former very hairy towards tip, and latter hairy. Formation of tarsus similar to *H. theivora* Femur—2·50 mm. Tibia—3·13 mm. Tarsus—·57 mm. *Intermediate & Fore legs*—Not unlike hind leg, but less dark in femur. Length—Intermediate. Fore. Femur— 2·20 mm. 2·00 mm. Tibia— 2·80 mm. 2·63 mm. Tarsus— ·57 mm. ·57 mm.	
THORAX ...	Entirely black. Coxæ luteous.	
ABDOMEN ...	Underneath—Black spot near lateral edge of every segment. Tip black. No other segments black. Above—Five segments and the tip more or less black right across, most intensely so at sides. General colour of abdomen ochraceous.	

Females.—Many samples caught in October, examined.

HEAD ...	Shape as with genus. Generally black, but much mixed with brownish ochraceous, patches of ochraceous behind bases of antennæ, and on the sides of the head. No tubercle noticed at base of antennæ.	Amount of ochraceous is very variable. Some samples show only small patches of black.
ANTENNÆ ...	Four-jointed—Joints about as hairy as with *H. theivora*.	
	First joint—Short, and incrassated most of the length, increasingly so to tip. Nodulose. Ochraceous with two narrow dark rings. Length—1·13 mm. (mean).	Length varies from 1·23 mm. to 1·03 mm.
	Second joint—Ochraceous with black tip. Thinner than first joint and not thickened. Length—3·22 mm. (mean).	Length varies from 3·43 mm. to 3·07 mm.
	Third joint—Much shorter than second joint. Black point at base and at tip. Length—2·74 mm. (mean).	Length varies from 2·90 mm. to 2·63 mm.
ROSTRUM ...	Colour as with male. Length—1·73 mm. 2nd joint—·34 mm. 3rd joint—·42 mm. 4th joint—·58 mm.	
PRONOTUM ...	Shape as with genus. *Collar*—Ochraceous with posterior portion dark. *Remainder of pronotum.*—Black patch extends ⅓ of the length from the posterior margin, crossed by two diagonally longitudinal ochraceous lines. Remainder ochraceous.	

Females.—Many samples caught in October, examined—(*concld.*)

Parts of Insect.	Typical characters.	Variation noticed.
Head and Pronotum.	Length—1·73 mm.	
Scutellum ..	Very dark or black.	
Scutellar Horn.	Lower ¼ black. Exactly as in male. Length—1·57 mm.	
Wings, Hemelytron.	As in *H. theivora*, but slight suffusion of black.	
	Apex and inner margin of cuneus bright red, the red sometimes extending to the vein in the membrane. Corium—Length—3·50 mm. Cuneus—Length—1·35 mm.	
Hindwing ...	As described for the male.	
Legs ..	As in male, but a little more reddish ochraceous. Length—	Length varies from
	Fore leg—Femur—2·76 mm.	2·90 mm to 2·63 mm.
	Tibia— 3·51 mm.	3·60 mm. to 3·40 mm.
	Tarsus— ·61 mm.	·63 mm. to ·60 mm.
	Intermediate leg—Femur—2·20 mm.	
	Tibia—2·80 mm.	
	Tarsus—·57 mm.	
	Fore leg—Femur—2·00 mm.	
	Tibia—2·63 mm.	
	Tarsus—·57 mm.	
Thorax ...	Anterior portion ochraceous.	
	Mesothorax—black.	
	Metathorax—ochraceous luteous.	
	Furrow down middle of pro and meso thorax.	
	Coxæ—luteous.	Coxæ—slightly variable in colour.
Abdomen ...	*Underside*—Ochraceous to stramineous except tip, segments posterior to origin of ovipositor, and ovipositor itself which are black.	
	Ovipositor double and very similar to *H. theivora*—1·37 mm. long.	
	Above—Much redder ochraceous than underside. Apex black ; next segment dark brown.	

The characters in which the species *Helopeltis cinchonæ* differs from others are,—

(1) The shortness of the first joint of the antenna in both male and female.

(2) The bright red colour of the apex and inner portion of the cuneus in both male and female.

(3) The luteous and erect character of the scutellar horn, together with small size of the clavate head relatively to that of the stalk in both male and female.

(4) The markings on the pronotum of the female.

The *Helopeltis cinchonæ* is found on cinchona at Munsong, British Bhotan, and also at Mungpoo, Darjeeling, at an elevation of 2,700 to 4,000 feet.

X.—GENERAL CONCLUSIONS.

We have now given the figures and observations made on a very large number of insects and can return to the problem stated at the commencement of this paper.

In the first place, it now appears certain that so far as tea is concerned, we have to deal at present with one species of *Helopeltis* occurring as a pest. The practical result follows that the methods for combating the pest successful in one district should be successful elsewhere. This is important, for so long as a doubt remained as a result of Bergroth's and of Watt's observation, it was quite possible to imagine that the persistency of the pest was due, in ome districts, to there being several insects, each with its own habits, involved in the attack. I have, however, shown conclusively now that the *Helopeltis febriculosa*, as described by Bergroth and Atkinson, comes well within the variation noticed for *Helopeltis theivora*, and that the observations give no indication of the presence of two distinct types under the latter. I should, in fact, be inclined to consider Bergroth's insect as not even a definite variety, but rather as a mere casual and individual variation. On the other hand, the insect attacking tea in Ceylon *Helopeltis antonii*, while the same as that which is a pest on cocoa, is quite different from that common in North-East India. As a result, even apart from climatic differences, which render the application of the methods difficult, it is by no means certain that the habits of the Ceylon insect are sufficiently near to allow of its being combated by the same remedies as its relative in North-East India. How far the same statistical study of the other species of *Helopeltis* hitherto described would lead to the assimilation of insects now arranged under different names, it is impossible to tell, as the only named species to which I have

had access is *Helopeltis romundei*, of which a few imperfect specimens exist in the Indian Museum. But these specimens are not sufficient to determine the matter even with regard to this one species, and I shall have to refer to a later date the examination of this question, when I have had the opportunity to see examples of other species as named by their originators.

In the meantime it may be well to call attention to these elements in the morphological character of *Helopeltis theivora*, which may be regarded as comparatively constant or eminently variable, as it is quite likely that the factors constant or variable in the present case will be found to be also respectively constant or variable in allied groups of heteroptera. I wish to insist on the point because very large numbers of species described have been named simply on account of slight difference in size or slight difference in colouring—matters which seem to be variable within quite large limits, and hence should hardly be used as primary differentiating characters.

In the first place, variations in size, even relatively large, apparently count for very little. In the case now under discussion, every organ of the body measured, with the exception of the rostrum and the wings, differed by more than twenty-five per cent. in size, the differences being somewhat more marked among the females than among the males. If we take the figures for the antennæ given on page 303, it will be noticed that for both the first and second joints only one insect of the total number examined in July is within the range of variation for February. This point is hardly so strikingly shown in the changes in size of other organs, but even with them, it is sufficiently so to make one hesitate, until the complete seasonal variation has been worked out, to create a new species because an insect is larger or smaller than another. Of course, there is a *mode* for each species, but that mode is evidently variable according to condition of growth.

Again, differences in colour are apt to be very misleading if made into primary differential characters, as has often been the case, especially among the heteroptera. In the present case

the differences are enormous, and many of them, as I have shown above (page 312), are simply due to the age of the adult insect from the last moult. If the insects were caught and killed as soon as this moult had taken place, nine out of ten observers would, probably, have named them as new species. But even apart from this, the variation in colouring due to season is also very marked. In *Helopeltis theivora*, the male is on the average (see pages 291 & 306), a much blacker insect in the height of the season (July—October), than in the colder weather, while the reverse is the case for the female. The colouring of the head, the pronotum, the abdomen, the thorax are all found to be eminently variable. The abdomen especially may be, as extremes, either quite a bright green or a luteous colour tending to ochraceous, and both with a variable amount of black. In each case it is shown to be absolutely necessary to determine the limits of both individual and seasonal variation before using colour characters as a principal means of determining species.

In the absence of these characters, it appears that the relationship of various parts to one another affords as good a means of making primary specific distinctions as can be suggested at the present time. But even here it is necessary to examine quite a number of insects, and use the average of measurements for the purpose. How this applies for *Helopeltis theivora*, is shown in the following two tables:

A.—*Relationship between joints of the antenna* (the first joint being taken as unity)—

	Males.			Females.		
	1st joint.	2nd joint.	3rd joint.	1st joint.	2nd joint.	3rd joint.
January	1·00	1·89	1·90	1·00	1·66	1·62
February	1·00	1·89	1·93	1·00	1·67	1·54
March	1·00	1·85	1·93	1·00	1·67	1·56
April	1·00	1·81	1·87	1·00	1·60	1·46
May	1·00	1·81	1·81	1·00	1·63	1·52
June	1·00	1·83	1·88	1·00	1·68	1·60
July	1·00	1·75	1·86	1·00	1·64	1·50
August	1·00	1·82	1·90	1·00	1·63	..
September	1·00	1·85	1·91	1·00	1·65	1·55
October	1·00	1·83	1·90	1·00	1·69	1·66
November	1·00	1·85	1·91	1·00	1·65	...
December	1·00	1·87	1·91	1·00	1·65	1·58

The constancy here is remarkable and marks off this species at once from the *Helopeltis antonii* from Ceylon in which we have—

	Males.			Females.		
	1st joint.	2nd joint.	3rd joint.	1st joint.	2nd joint.	3rd joint.
February (tea)	1·00	1·82	1·51	1·00	1·70	...
November (cocoa)	1·00	1·90	1·60	1·00	1·83	1·23

The numbers examined in this latter case are hardly sufficient to make these ratios quite certain, but it is clear how different this latter is from that in *Helopeltis theivora.*

B.—*Relationship between the first joint of the antenna and the hind femora* (the first joint of the antenna being again taken as unity)—

	Males.		Females.	
	1st joint of Antenna.	Hind Femur.	1st joint of Antenna.	Hind Femur.
January	1·00	1·04	1·00	1·10
February	1·00	1·06	1·00	1·07
March	1·00	1·03	1·00	1·07
April	1·00	·97	1·00	1·00
May	1·00	1·01	1·00	1·05
June	1·00	1·03	1·00	1·05
July	1·00	1·00	1·00	1·05
August	1·00	1·01	1·00	1·02
September	1·00	1·01	1·00	1·01
October	1·00	1·00	1·00	1·03
November	1·00	1·04	1·00	1.01
December	1·00	1·00	1·00	1.04

The constancy here is almost as great as in the previous case. *Helopeltis antonii* gave the following figures :—

	Males.		Females.	
	1st joint of Antenna.	Hind Femur.	1st joint of Antenna.	Hind Femur.
February (tea)	1·00	1·08	1·00	1·09
November (cocoa)	1·00	1·18	1·00	1·19

Again, though the numbers examined in the last case do not warrant any definite conclusion as to what the ratio actually would be for the species, it is evidently different from that for *Helopeltis theivora.* On the whole, therefore, I am led to conclude that the accurate measurement of the *relative* size of

several of the parts of a number of insects should be one of the primary factors in determining the specific position of any example, at any rate among the heteropterous bugs. The colouring and to a certain extent the size, provided the limits of variation be known, should also come into the question, but the correlation of parts seems to be the best basis on which to work. The determination of such proportion needs, of course, the possibility in most cases of dissecting and measuring a quite large series of insects. The parts to be used in each case, too, cannot be determined without the measurement of a fairly considerable number of individuals. The use of such a method, however, would prevent, in a large measure, new species being created to receive single specimens, unless they were very markedly different from any existing type, and would be well worth the trouble if it led to some sort of finality in entomological nomenclature, through which, at present, only a few specialists are able to find their way.

BIBLIOGRAPHY.

1. Signoret ... Note sur les Hemipteres Heteropteres de la famille des unicellules. Annales de la Société Entomologique de France. 3rd Series, Vol. VI., page 502 (1858).
2. Peal, S. E. ... The Tea Bug of Assam, Journal Agri.-Horticultural Society of India. Vol. IV. (New Series), p. 127 (1874).
3. Wood Mason ... The Tea Bug of Assam (1884). Calcutta.
4. Waterhouse, C. O. ... Some observations on the Tea-bugs (Helopeltis) of India and Java. Transactions, Entomological Society of London (1886), pp. 457-459.
5. Bergroth, E. ... Notes on two capsidæ attacking the cinchona plantations in Sikkim. Entomologist's Monthly Magazine, May 1889, p. 271.
6. Atkinson, E. J.... Rhynchota. Indian Museum Notes, Vol. I., p. 175 (1890).
7. Cotes, E. C. ... An Account of the Insects and Mites which attack the Tea Plant in India. Calcutta, 1894.
8. Dudgeon, G. C. ... Notes on the Oviposition of *Helopeltis theivora*, Waterhouse. Indian Museum Notes, Vol. III., No. 5, p. 33 (1895).
9. Watt, G. ... The Pests and Blights of the Tea Plant. 1st Edition. Calcutta, 1898.
10. Green, E. E. ... Circular, Royal Botanic Gardens, Ceylon. (1901), Series 1, No. 21. Also (1902), Vol. II., No. 2.

11. Mann, H. H. ... Note on a disputed point in the life History of *Helopeltis theivora*. Journal Asiatic Society of Bengal, 1902.

12. Mann, H. H. ... The Mosquito Blight of Tea. Indian Tea Association's Scientific Series, Calcutta, Part I. (1902), Part II. (1904), Part III. (1905).

13. Watt, G., and Mann, H. H.... The Pests and Blights of the Tea Plant. 2nd Edition. Calcutta, 1903.

14. Mann, H. H. ... Notes on *Helopeltis theivora*, the "Mosquito Blight" of Tea. Indian Museum Notes, Vol. VI., No. 1, page 5, 1903.

15. Distant, W. L. ... The Fauna of British India, Rhynchota. Vol. II., p. 440, London, 1904.

16. Mann, H. H. ... The Relative Proportion of the Sexes in *Helopeltis theivora*. Journal Asiatic Society of Bengal (New Series), Vol. II., No. 5 (1906).

EXPLANATION OF PLATES

HELOPELTIS CINCHONAE.—

1. Male of *Helopeltis Cinchonæ*.
2. Female of *Helopeltis Cinchonæ*.
3. Hemelytron.
4. Hind wing.
5. Tip of Scutellar horn.
6. Rostrum.
7. Scutellar horn.
8. Antenna.

THE COCCIDÆ ATTACKING THE TEA PLANT IN INDIA AND CEYLON.

By E. E. GREEN, F.E.S., F.Z.S.,

Government Entomologist, Ceylon,

AND

HAROLD H. MANN, D.SC.,

Scientific Officer to the Indian Tea Association.

I.—INTRODUCTION.

The present paper is designed to bring together the scattered information regarding the scale-insects attacking the tea plant in India and Ceylon, and especially to give a formal description of several new species occurring in India which have been discovered during the investigations of which it is the outcome.

As shown in the following list, the tea-plant in India and Ceylon is infested by a considerable number of scale-insects. Fortunately, very few of them are of serious consequence at present. But with Coccidæ—even more than with other phytophagous insects —every species must be regarded as a potential enemy, and treated accordingly. A species that for years may have existed only in small numbers, may suddenly, through some unforeseen and unrecognized change in its conditions and environment, multiply to a really dangerous extent.

Of all insect pests, members of this family are perhaps the most difficult to control. They are mostly small and inconspicuous and so escape notice until they have become firmly established. They increase very rapidly, many of them parthenogenetically.

The minute larvæ can subsist without food for considerable periods and may be unconsciously transported for long distances upon clothing or in the hair of animals and feathers of birds. They can penetrate crevices in the bark and conceal themselves in the buds and beneath the scales of plants. In this manner they are frequently transported from one country to another upon living plants. Many species protect themselves with waterproof coverings and so resist the action of insecticides.

In a word, the Coccidæ, as a family, must be looked upon as one of the important groups, if not the most important group of insect-pests in tropical and semi-tropical countries, and well warrant the attention that is now being paid to them in all parts of the world.

II.—LIST OF COCCIDÆ AFFECTING THE TEA PLANT IN INDIA AND CEYLON.

1. Icerya ægyptiaca (Douglas).

   (*Crossotosoma ægyptiacum*, Dougl.). 'Ent. Mo. Mag.,' xxvi., p. 79 (1890).

   Ceylon.

2. Orthezia insignis (Douglas).

   'Jn. Quekett Micr. Club,' p. 169 (1887).

   (*nacrea*, Buckton), 'Ind. Mus. Notes,' iii, p. 103 (1894); 'Ind. Mus. Notes,' iv, p. 25 (1896).

   'Pests and Blights of the Tea Plant,' 2nd ed., p. 310 (1903).

   Ceylon.

3. Cerococcus ficoides (Green).

   'Ent. Mo. Mag.,' xxxv, p. 225 (1890).

   'Pests and Blights of the Tea Plant,' 2nd ed., p. 316 (1903).

   Duars.

4. DACTYLOPIUS CITRI (Risso).

'Essai Hist. Nat. des Oranges' (1813).

Ceylon.

5. DACTYLOPIUS THEÆCOLA (Green).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 317 (1903).

Assam; Darjeeling.

6. TACHARDIA DECORELLA (Maskell).

'Trans. N. Z. Instit.,' xxx, p. 247 (1892).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 317 (1903).

Assam; Darjeeling.

var. *theæ* (Green).

Assam; Darjeeling.

7. CERONEMA JAPONICA (Maskell).

'Trans. N. Z. Instit.,' xxx, p. 234 (1898).

'Ind. Mus. Notes,' v, No. 1., p. 11 (1900).

India (no locality given).

8. ERIOCHITON THEÆ (Green).

'Ind. Mus. Notes,' v, No. 1, p. 10 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 310 (1903).

Darjeeling.

9. PULVINARIA PSIDII (Maskell).

'Trans. N. Z. Instit.,' xxv, p. 223 (1892).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 310 (1903).

Nilgiris, India: Ceylon.

10. Ceroplastes ceriferus (Anderson).

'Mon. Cocci ceriferi' (1791).

'Ind. Mus. Notes,' i, p. 189 (1890).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 316 (1903).

Assam : Terai : Darjeeling : Cachar : Ceylon.

11. Ceroplastes floridensis (Comstock).

'Rep. U. S. Dep. Ag.,' 1880, p. 331 (1881).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 316 (1903).

Assam : Darjeeling : Ceylon.

12. Ceroplastes rubens (Mask).

'Trans. N. Z. Instit.,' xxv, p. 214, (1892).

[Erroneously attributed to C. Myricæ (Linn.)]

'Ind. Mus. Notes,' v, No. 1, p. 8 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 314 (1903).

Assam.

13. Lecanium discrepans (Green).

'Cocc. Ceylon,' pt. iii, p. 204 (1904).

(= similans). 'Pests and Blights of the Tea Plant,' 2nd ed., p. 314 (1903).

Ceylon.

14. Lecanium formicarii (Green).

'Ind. Mus. Notes,' iv, p. 10 (1896).

'Cocc. Ceylon,' pt. iii, p. 190 (1904).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 314 (1903).

Ceylon.

15. Lecanium hemisphæricum (Targ.).

'Studii sul. cocc.,' p. 26 (1867).

'Ind. Mus. Notes,' iii, No. 4, p. 41 (1894).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 313 (1903).

'Cocc., Ceylon,' pt. iii, p. 232 (1904).

Assam : Duars : Ceylon.

16. Lecanium nigrum (Nietner).

'Enemies of Coffee Tree,' p. 9 (1861).

'Ind. Mus. Notes,' i, p. 117 (1889), and iv, p. 9 (1896).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 312 (1903).

'Cocc. Ceylon,' pt. iii, p. 229 (1904).

South India : Ceylon.

17. Lecanium viride (Green).

'Ent. Mo. Mag.,' xxv, p. 248 (1889).

'Ind. Mus. Notes,' i, pp. 49, 117 (1889); ii, p. 168 (1893); iii, No. 6, p. 18 (1894).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 312 (1903).

'Cocc. Ceylon,' pt. iii, p. 199 (1904)

South India: Ceylon.

18. Lecanium Watti (Green).

'Ind. Mus. Notes,' v, p. 6 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 314 (1903).

Sibsagar, Assam.

19. Chionaspis biclavis (Comstock).

'2nd Rep. Dep. Ent. Corn Univ.,' p. 98 (1883).

'Ind. Mus. Notes,' iv, p. 2 (1896).

'Cocc. Ceylon,' pt. ii, p. 152 (1899).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 309 (1903).

Ceylon.

20. Chionaspis Manni (Green).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 309 (1903).

Assam : Darjeeling : Kangra Valley.

21. Hemichionaspis separata (Green).

'Ind. Mus. Notes,' v, No. 1, p. 5 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 309 (1903.)

Darjeeling.

22. Hemichionaspis theæ (Maskell).

'Ind. Mus. Notes,' ii, No. 1, p. 60 (1891) ; No. 6, p. 168 (1893) : iii, No. 1, p. 25 (1893); No. 4, p. 39 (1894) ; iv, p. 3 (1896).

'Cocc. Ceylon,' pt. ii, p. 113, (1899).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 730 (1903).

Throughout the tea Districts of India : Ceylon.

23. Diaspis pentagona, var. *theæ* (Maskell).

'Trans. N. Z. Instit.,' xxvii, p. 389 (1896).

'Ind. Mus. Notes,' v, p. 12 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 310 (1903).

India (no locality given).

24. Fiorinia fioriniæ (Targ.)

'Studii sul. Cocc.,' p. 14 (1867).

'Cocc. Ceylon,' pt. i, p. 94 (1896).

'Ind. Mus. Notes,' iv, p. 5 (1896).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 307 (1903).

Ceylon.

25. Fiorinia theæ (Green).

'Ind. Mus. Notes,' v, p. 3 (1900).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 306 (1903).

Assam ; Kangra.

26. Aspidiotus camelliæ (Signoret).

'Ann. Soc. Ent. Fr.' (4), ix, p. 117 (1869).

'Cocc. Ceylon,' pt. i, p. 60 (1896).

'Ind. Mus. Notes,' iv, p. 4 (1896).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 303 (1903).

Assam ; Darjeeling ; Southern India ; Ceylon.

27. Aspidiotus cyanophylli (Signoret).

'Ann. Soc. Ent. Fr.' (4), ix, p. 119 (1869).

'Cocc. Ceylon,' pt. i, p. 51 (1896).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 305 (1903).

Ceylon.

28. Aspidiotus destructor (Signoret).

'Ann. Soc. Etn. Fr.' (4), ix, p. 120 (1869).

'Ind. Mus. Notes,' ii, No. 6, p. 168 (1893) ; iii, No. 1, p. 66 (1893).

'Cocc. Ceylon,' pt. i, p. 49 (1896)—(wrongly attributed to *lataniæ*).

Ceylon.

29. ASPIDIOTUS DICTYOSPERMI (Morgan).

'Ent. Mo. Mag.,' xxv, p. 352 (1889).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 305 (1903).

Kangra.

30. ASPIDIOTUS LATANIÆ (Signoret).

'Ann. Soc. Ent. Fr.,' ix, p. 124 (1869).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 306 (1903)—(= *Cydoniæ*).

Ceylon.

31. ASPIDIOTUS THEÆ (Maskell).

'Ind. Mus. Notes,' ii, p. 59 (1891).

'Pests and Blights of the Tea Plant,' 2nd ed., p. 304 (1903).

Kangra.

(ASPIDIOTUS NERII—*see* 'Pests and Blights,' p. 306—is wrongly recorded from Ceylon).

III.—DESCRIPTIONS OF NEW SPECIES. (E. E. Green.)

The following species among the above are here formally described for the first time.

CHIONASPIS MANNI, spec. nov.

Female puparium (fig. 2), of irregular form; broadly dilated posteriorly; usually curved. Exuviæ at anterior extremity pro-

jecting beyond margin of scale : larval pellicle fulvous ; nymphal pellicle castaneous, more or less concealed beneath a thin coating of greyish secretion : pygidial margin with prominent median lobes (fig. 2). Secretionary area dead white, but usually discoloured by a superficial admixture of particles of bark and other foreign matter. Length, 2·30 to 2·80 mm. Breadth, 1·10 to 2·15 mm.

Male puparium (fig. 3), elongate, narrow ; not carinated ; smooth and closely felted, the ventral as dense as the dorsal area, the terminal third slightly depressed. Pellicle fulvous, attached by the anterior half of the larval pellicle ; the remaining portion more or less erect : (fig. 4). Length, 1·75 to 2 mm. Breadth about 0·60 mm.

Adult ♀ of normal form : narrowest in front, broadest across abdominal area. In the early adult ♀ (fig. 5), the pygidium occupies fully a third of the whole area : later the thoracic segments increase in size. Prothoracic segment with four conspicuous oval or circular scars (fig. 7), anterior spiracles with parastigmatic glands. Divisions of abdominal segments usually well defined. Dorsal pores very conspicuous both on pygidium and on hinder margin of abdominal segments, where they are unusually numerous (fig. 6). Besides the larger oval pores, there are some small circular pores on the anterior ventral margin of abdominal and prothoracic segments. There are numerous stout spiniform squames on the latero-ventral area of abdominal segments—only a few of them projecting beyond the margin. Pygidium rounded or obtusely pointed. Median lobes large, prominent, their bases confluent, the apices rounded, divergent ; occupying a shallow median cleft, projecting far beyond the margin (fig. 8). Free margin of median lobes (in early adult example) minutely serrate : in older examples smooth (fig. 9). Second lobes duplex, prominent, narrow, the inner lobule usually somewhat dilated. Other lobes obsolescent, represented only by small marginal more or less chitinized prominences, each supporting a large oval pore. Circumgenital glands in five groups with very numerous orifices. Anal orifice near base of pygidium. Examples from *Ficus* and *Solanum* (otherwise iden-

tical) have the median lobes less prominent (in varying degree). Length of fully matured examples averaging 1·00 mm.

On twigs and branches of the tea plant (Assam and Darjeeling. Coll. H. H. Mann), on *Ficus* sp. (Kangra valley), and *Solanum melongena* (Calcutta, Coll. I. H. Burkill). A remarkable phenomenon associated with this species is the production of irregular woody swellings surrounding the groups of scales (fig. 1). The swelling is not superficial but involves the deeper woody tissues of the plant. It is not noticeable where the scales are attached to succulent plants, such as *Solanum*. I have noticed a similar phenomenon with typical *Diaspis pentagona*, which induces hard woody swellings on stems of *Flacourtia*, but not upon more succulent plants which it may attack. Female puparia scattered: male puparia in dense erect clusters.

There may be some question as to the correct genus in which this species should be placed. It has characters intermediate between *Chionaspis* and *Diaspis*, with a suggestion of *Mytilaspis* in the uncarinated male puparia. The female puparium is distinctly chionaspiform, the pellicles being placed at, and extending beyond the extreme anterior margin. The form and disposition of the male puparia resemble very closely those of *Diaspis pentagona* (= *amygdali*), but show absolutely no trace of carination. The characters of the female pygidium—taken alone—are again remarkably similar to *D. pentagona*, but may be distinguished by the proportionately greater size and more rounded extremities of the median lobes (those of *D. pentagona* being irregularly conical and more coarsely dentate). The differences are still more marked on comparison of the nymphal pellicles, the median lobes of *Manni* being narrower and more widely divergent and the second lobes minute and almost obsolete (fig. 10); while in *D. pentagona* the second lobes are strongly developed and conspicuous. The elongate form of the female puparium, taken in conjunction with the total absence of carination in the male puparium would by the usual classification based solely upon the characters of the puparia necessitate the inclusion of the species in the genus *Mytilapsis*: but I feel convinced that it is really more nearly related to members of the *Chionapsis* group.

Fig. 1. Tea branch with ♂ and ♀ scales, natural size (showing swellings due to presence of the insects).

„ 2. ♀ puparium × 24.

„ 3. ♂ „ × 24.

„ 4. Part of cluster of ♂ puparia showing manner of attachment to branch, × 12.

„ 5. Early adult ♀ ventral view, × 45.

„ 6. Pygidium of ♀ × 150.

„ 7. Anterior extremity of adult ♀ showing thoracic scars, × 55.

„ 8. Pygidial margin of adult ♀ (from tea plant), × 380.

„ 9. „ „ „ („ Ficus), × 380.

„ 10. Nymphal pellicle of ♀ (from tea plant), × 55.

DACTYLOPIUS THEÆCOLA, spec. nov.

Adult female (as received in dry condition and detached from its support) more or less completely covered with white mealy secretion, the parts of the body where the covering has been rubbed off showing reddish brown.

After maceration and preparation for the microscope (fig. 11), the most characteristic features are the exceptionally stout legs and the series of prominent rounded tubercles at the posterior extremity of the body.

Antenna (fig. 12) normally 7-jointed: but the division between the 3rd and 4th joints is less strongly marked than the others, is sometimes very inconspicuous, and occasionally indicated only by a slight constriction (fig. 13). The antennal formula is very variable, but the 3rd and 4th joints are always subequal, and the 7th considerably longer than any of the others.

Legs (fig. 14) very stout, evidently adapted for a fossorial habit. Tibia and tarsus relatively short. These two joints, with the claw, together equal the length of the femur (without trochanter). Claw (fig. 15) stout and falcate, the tip with a well-marked laminate

carina on the outer edge. I can find no trace of digitules in any of my examples.

Extremity of abdomen with from 6 to 8 prominent rounded tubercles, bearing numerous short stout spines ; similar groups of small spines on the margins of all the other segments. There are two pairs of large and conspicuous oval glandular scars on the dorsum, one pair on the cephalothorax shortly in front of the anterior limbs ; the other pair at the junction of the penultimate and antepenultimate segments. Anal ring bearing 6 stout but inconspicuous hairs, and surrounded by a series of about 16 somewhat finer hairs. Derm, especially on the dorsal surface, closely but inconspicuously dotted with minute circular pores.

Length 1·50 to 2·60 mm. Breadth 1 to 2·30 mm.

On roots of tea plants. Assam and Darjeeling (India). Collected by Dr. H. H. Mann.

Fig. 11. Adult female, ventral view, × 50.
,, 12, 13. Antenna, × 250.
,, 14. Anterior leg, × 100.
,, 15. Claw, × 450.

Tachardia decorella,—var. theæ, n. var.

Tachardia decorella, Maskell. 'Trans. N. Z. Instit.,' xxv, p. 247 (1892).

Tachardia decorella, Maskell. 'Ind. Mus. Notes,' iv, No. 2, p. 58 (1896).

Differs from typical examples from Australia in the corrugations of the ♀ test being broken into more or less distinct rounded tubercles (fig. 16). These corrugations may extend to the margin, but usually stop short of it. Colour dull brown. Length 2·50 mm.

The ♀ puparium (fig. 17) is smoother than in type : without any trace of corrugation. Hinder extremity slightly elevated. Colour reddish. Length 1·50 mm. (It is doubtful if Maskell's figure of the ♂ puparium really represents that stage. It is more probably the larval test).

The ♀ insect (fig. 18) differs from the Australian type, chiefly in the larger size and greater distinctness of the pores in the marginal gland groups ; and in the form of the perforate plate on the stigmatic processes, which are equilaterally triangular in typical *decorella*, but elongately triangular in var. *theæ*.

Collected by Dr. H. H. Mann on tea plants in Darjeeling, February 1907. Also in Assam, December 1900.

I have not seen the Indian examples originally submitted to Maskell. But examples received from the Indian Museum (Coll. H. H. Mann, December 1900), are identical with those now under consideration. Examples received (through Mr. Burkill) from Cinchona Calisaya (Government Cinchona Plantation, Mungpoo, Darjeeling), appear to be of the typical form.

Fig. 16. *Tachardia decorella*, var. *theæ*, ♀ test dorsal aspect, × 15.

Fig. 17. *Tachardia decorella*, var. *theæ*, ♂ puparium, dorsal aspect, × 15.

Fig. 18. *Tachardia decorella*, var. *theæ*, ♀ insect, removed from test, dorsal aspect, × 35.

IV.—DISTRIBUTION AND RELATIVE IMPORTANCE OF SCALE-INSECTS ON TEA IN NORTHERN INDIA. (H. H. Mann.)

The scale-insects described or referred to above are of very different importance. So far as the Indian tea districts are concerned, it may be said that the damage done by any of them has never been really serious except in the high level districts of Darjeeling and Kangra. Elsewhere they have been looked upon as curiosities, and it has rarely been possible to find more than a few plants affected on any tea estate.

Undoubtedly the most widespread and common coccid on tea is *Hemichionaspis theæ*, whose white male scales are very conspicuous. It occurs everywhere in the Assam Valley where "China" or "Hybrid" bushes are grown, and more particularly where, in

pruning, a large number of the feebler and weaker shoots are left in the bushes. In the Darjeeling district, and more especially on the estates in the neighbourhood of Kurseong, it ranks as one of the commonest pests of the tea plant. This species is only, in our experience, found on the leaves of the plant, but while the male scales are almost exclusively on the upper surface, the female are found indiscriminately on the upper and lower surfaces. The latter, except where the pest is exceptionally serious, are much fewer in numbers than the former. In the early part of the year, after pruning (February to June), the amount of this pest is small, but with the advent of the monsoon, the numbers rapidly increase, until, by the end of October, blocks of tea are sometimes white with the male scales. Its presence has hitherto been usually neglected, and we are not aware of any case in which vigorous measures have been taken to deal with the pest. Usually the damage which it does is stated to be small, but accounts are on record of young plants in nurseries having been actually killed by this insect in the Darjeeling district. This, however, has very rarely occurred.

Equally widespread, but rarely appearing so prominently, are *Fiorinia theæ* and *Lecanium hemisphericum*. Both of these may be stated to be more frequently Assam or Duars than Darjeeling pests. The latter has been found, not uncommonly, on apparently very healthy tea on a number of estates in the Dibrugarh, North Lakhimpur, and Bishnath districts of Assam, and has been found in quantity on a *Duranta* hedge adjoining tea in the first-named district. It is always found, on the tea bush, in a sheltered part of the plant, generally on stems protected by a dense leafy covering, and can be most frequently seen in the latter part of the rainy season. It is more often found on the young woody twigs of the tea, less than one year old, but also on the underside of the leaves. The damage hitherto attributed to this insect has been small.

The only other one of the insects mentioned, whose distribution is at all general, is *Tachardia decorella*, either in the typical form, or in the new form described in the present paper. It is common in Darjeeling, being found in almost every corner of the district on isolated bushes, and is not infrequent in several of the

Assam districts. In the Bishnath district we have noticed it completely ruin a bush, the whole of the stems being covered with the scales, but such a case has always been an isolated one. It is always found on the stem of the plant, and indiscriminately on the young and old wood.

An instance of the sudden breaking out into prominence of a coccid which has been known for many years, is that of *Ceroplastes ceriferus* in Cachar. Hitherto, though we have collected it in Assam, Terai, and Darjeeling, it was looked upon as a curiosity. During the early part of 1907 it has appeared, however, in epidemic form on several gardens in Cachar, being found on large numbers of bushes over a considerable acreage. The insect was noticed particularly in February and March 1907, and occurred almost entirely on wood more than one year old.

In the Darjeeling district there are two other scale insects which do considerably more harm than any of the aforementioned, and are really serious tea pests. These are *Eriochiton theæ* and *Chionaspis Manni.*

Eriochiton theæ is the more obvious of these, owing to the constant association of a black fungus (*Capnodium Footii*) with it. It was first collected from Thurbo, an estate near the border of Nepal in 1897, but has now been found on tea in almost every valley in the Darjeeling district. It attacks isolated bushes on both sides of the leaves, on the young and on the old stems. It can hardly be seen before June, but during the rains grows with very great rapidity, until by October and November the stem on which it occurs is almost or entirely killed. Kerosene emulsion has been tried on this insect with little effect, but considerable success has attended the use of rosin soap-caustic soda mixture to the stems after the pruning is completed.

Chionaspis Manni, the other more serious coccid pest in Darjeeling, was found by one of the authors on a tea estate in the Balasun Valley in 1901. It has since been noticed in almost every valley in the district. According to observations made in 1906, when occurring in Darjeeling, it invariably occurs on isolated bushes containing old and non-yielding wood. Whether the hardness

and non-yielding character of the wood was the consequence of the presence of the insect, or only allowed the latter to obtain a start, could not be ascertained, but every case noted during September and October occurred on a bush which would have been marked for 'heavy-pruning' as a result of its condition at the time. It was never found on wood less than one year old, nor on bushes which had a good leafy cover, but usually on stems fully exposed to the sun. Most of the examples of this coccid were, however, found in north-eastern slopes. If this scale-insect can be held, as seems probable, to be the cause of the unyielding character of the bushes on which it occurs, its presence becomes very serious, though hitherto the isolated character of its attacks had prevented very general attention being drawn to it. No experiments have, hitherto, been made as to the best method of eradicating this pest.

A good deal of interest attaches to *Dactylopius theœccola*, one of the new species described in the present paper, owing to the fact of its being the only coccid attacking the roots of tea hitherto described, and to the present limited character of its distribution. It has only been recorded from two or three estates at an elevation of from 2,000 to 3,000 feet in the neighbourhood of Darjeeling, and attention was drawn to it by the fact of extreme activity of black ants in the neighbourhood of the bushes. On digging round the plants, which were some of the most vigorous and flourishing on the estate, it was found clinging to the bark of the root just under the surface of the ground. In a few cases, where soil had accumulated round the main branches of the bushes, it was found under the soil in these also. It is apparently active throughout the whole of the season when the soil is moist, but when the rain becomes heavy the insects descend lower in the ground, and have been found on some of the branch roots of the tea plant. Hitherto no appreciable damage has been done by this insect, which has been found only on 'high-class hybrid' or on 'Assam-indigenous' bushes, and the anxiety among planters which was felt in the matter on the first discovery of the insect has now completely died away.

The remainder of the scale-insects recorded in the above list as occurring in the Indian tea districts (with the exception of

Aspidiatus theæ from the Kangra Valley, of which we have no experience from the practical point of view) have been up to the present, only curiosities, and have not been frequently enough observed to make possible more than a passing notice of their occurrence on the tea plant in Northern India.

V.—DISTRIBUTION AND RELATIVE IMPORTANCE OF SCALE INSECTS ON TEA IN SOUTH INDIA AND CEYLON (E. E. Green).

In Southern India, *Aspidiotus camelliæ* Sign. has recently attracted attention as a tea pest. Examples received from an estate in Coonoor show that this species must be considered of importance. As noticed in Ceylon, this is more particularly a pest of young tea, up to the second or third year of growth. In the Coonoor specimens, the scales were massed upon the young stems and had practically killed the upper parts of the plant. Fresh healthy shoots were reported to be springing up from below the injured parts, but unless prompt remedial measures were undertaken, these new shoots would soon be infected. In the case of very young plants, wholesale removal and destruction by fire would be the only practicable treatment. With more advanced plants, collar pruning could be resorted to. It should be clearly understood that when once the plant is affected, it is a source of danger to its neighbours. The prunings should be destroyed on the spot. Removal to other parts of the field will almost certainly result in sowing the pest along the route of transport.

As regards tea in Ceylon, there have been one or two scares from the sudden appearance of *Orthezia insignis* on fields adjoining lantana scrub. Tea so affected is certainly warranted to cause alarm. This pest affects the young shoots of the plant and is found to be swarming even on the flush. It is fortunately a conspicuous insect and cannot well be overlooked. The several outbreaks that have occurred have always received prompt attention,

pruning and burning being the treatment adopted. At the same time the boundaries have been cut well back and fired. Such measures have invariably been successful in checking the pest and preventing its recurrence. It appears that *Orthezia* does not readily adopt a tea diet; but it is probable that—if left undisturbed on the tea, subsequent generations of the insect would soon accustom themselves to the change of food plant.

Pulvinaria psidii has sometimes occurred in considerable force on localized sheltered patches of tea. It is accompanied and rendered conspicuous by a copious growth of black fungus (species of *Meliola* and *Capnodes*) which covers the leaves as if with a shower of soot. The pest does not seem to spread to any extent and is largely kept in check by a dipterous insect that breeds in the ovisacs of the bug and destroys the eggs.

Lecanium formicarii is sometimes troublesome, chiefly on account of its attendant ant (*Cremastogaster dohrni*) which constructs brown-paper-like nests around the colonies. This ant is very pugnaceous and resents any disturbance of the bush in which it has set up its establishment. The destruction of the nests and the application of Macdougal's insecticide or kerosene emulsion to the infested branches has been found sufficient to keep the pest in check.

Lecanium hemisphæricum causes some injury to individual bushes, but usually confines its attacks to plants that are sheltered from rain by overhanging rocks.

Chionaspis biclavis is perhaps the most serious and widespread of all Coccidæ affecting the tea plant in Ceylon. It is the more dangerous because it is so seldom recognized, the scale being concealed by the incorporation of the natural fibres of the bark. Its presence may, however, be detected by the pimply appearance of the bark. After the death of the insect, the bark often becomes thickly encrusted by a dense velvety purplish fungus. Its attacks result in an unhealthy hidebound condition of the main stems and branches. The usual treatment consists of the excision of the worst affected stems, during pruning, and scrubbing the remainder with a pad of coir matting moistened with kerosene emulsion.

This species has not yet been recorded from India, but it may very possibly exist—unrecognized—in the southern districts.

Aspidiotus camelliæ is a pest of young tea plants, as in Southern India ; but does not give very much trouble in Ceylon, now that few new clearings are being opened.

THE MUSTARD SAWFLY (*ATHALIA PROXIMA*, KLUG).

By

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist,

AND

C. C. GHOSH, B.A.,

Assistant to the Imperial Entomologist.

The genus *Athalia* is placed in Kirby's "List of Hymenoptera," Vol. I, at the head of sub-family XI, *Athaliinæ*, and includes a total of 17 species found in Europe, Asia, and Africa.

The only Indian species is *A. proxima*, Klug, which stands as follows in this list :—

Tenthredo (Allantus) *proxima*, Klug, Berl. Mag. VII, p. 130, n. 5 (1816).

Athalia tibialis, Cam. Trans. Ent. Soc. Lond., 1876, p. 460.

Expanse, al. 6-7 lin., long. corp. 3 lin.

Luteous, shining ; head, hinder half of thorax above, tarsi, hind tibiæ, upper side of the other tibiæ, and sheaths of saws black ; palpi pale testaceous ; lower edge of clypeus (occasionally) white. Wings smoky hyaline, with black nervures ; tegulæ luteous.

Male with the two basal joints of antennæ beneath and apex of clypeus, with the labrum, white ; clypeus very hairy, spurs pale.

Klug described this species as from Baltimore, but no other authority for the occurrence of an *Athalia* in America exists ; and after a careful examination of his description, I have no doubt that he had this common Indian species before him.

Hab. India.

a-g. (Types of *A. tibialis*). Barrackpur?—Sir J. Hearsey.

The description of Cameron's *A. tibialis* gives the locality as ? E. Indies ; Kunow's list of Tenthredinidæ in *Genera Insectorum* gives "India" and there appear to be no further references to this species.

Distribution.

This species has been found abundantly in the neighbourhood of Surat, Baroda, Ahmedabad and probably occurs throughout Gujrat ; at Bassein near Bombay ; at Poona in the Deccan. It has been observed at Nagpur and other places in the Central Provinces by the Entomological Assistant, Ratiram Khamparia ; it is known from Calcutta ; it has occurred every year in abundance at Pusa in Behar and apparently is common over Behar ; it has been observed in Cawnpore ; Mr. C. S. Misra, Assistant to the Entomologist, observed it in abundance on cruciferous crops in the Assam valley. In the Punjab it has been found at Lahore by Vishwa Nath Sahai, Entomological Assistant. It is apparently general in the plains over India north of a line drawn from Calcutta to Bombay ; it has as yet been only once reported from Madras, the Entomological Assistant of the Agricultural Department having reared it in the Shevaroys.

Food-Plants.

This pest was first found in the vegetable gardens near Surat, where it was destructive to cabbage. It has also been found to feed upon mustard, rape, sarson, torai and other cultivated varieties of *Brassica*, upon radish (*Raphanus sativus*) and halim

(*Lepidium sativum*). No wild food-plants have been found, but as its known food-plants are *Cruciferæ*, it is likely to be found on wild species of this natural order also.

Occurrence.

This insect has been under close observation at Pusa for three cold weathers and the intervening periods. It was first seen in the cold weather of 1904-05, feeding in some number upon rape, mustard and all varieties of *Brassica*, cultivated as field crops. The damage done was negligible, since the larvæ, though in fair number, were scattered and neither developed quickly nor increased rapidly in number. At the close of the cold weather it disappeared and no efforts availed to find it during the ensuing hot weather and rains. Early in the following cold weather (10th November 1905) as the young mustard crops came up, it was seen again, the imago being captured in the fields. The life history was then worked out, as described below, and a number were reared with the object of determining exactly its behaviour during the year. As is described below, Mr. Ghosh found that all the full-grown larvæ remained dormant throughout the hot weather and rains, then emerging within about three weeks. At the same time, the imagines were captured in the field, and on the 1st November larvæ were found on volunteer mustard.

We are justified in accepting the fact that this insect in Pusa is active from about October 15th to about March 15th, and then enters upon a period of repose as a resting larva. This applies to the great majority, but we are not in a position to say what happens to an imago hatching out, for instance, in March. Typically the species passes the dry hot weather and rains as a dormant larva.

In Surat and Baroda, the larvæ are found as early as June and normally appear in August and September. We have observed this in two seasons and we may assume that the

following paragraph in Indian Museum Notes refers to the same insect: (Indian Museum Notes, Vol. IV, No. 1, p. 32, 1896).

> "The following is taken from a report, dated 10th August 1894, by Mr. J. H. Middleton, Professor of Agriculture, Baroda College, forwarded by the Survey Commissioner and Director of Land Records and Agriculture, Bombay:
>
> "Hymenoptera, Sawfly.—The larva of a sawfly attacks cabbage and most of the other plants of this family. Specimens were sent to the Museum, but without the *imago* they could not be named. I have attempted several times to rear the insect, but the grubs are very delicate and I have not yet succeeded.
>
> "The larva is greenish black and about $\frac{1}{2}''$ long when full grown; it eats round the edges of the leaf and rapidly destroys seedlings.
>
> "This pest appears in September and passing through successive generations lasts for six months or more. It is especially bad in cloudy weather.
>
> "This insect is referred to in Volume III, No. 5, page 69, of these *Notes*."

The habits of the insect in this case are different from those observed elsewhere, and until further and far more extensive records are available, the behaviour of the pest cannot be predicted.

In Nagpur, in the Central Provinces, the insect has been captured or reared in November, December and January only, and in these months in considerable number. The same is true of Lahore, Cawnpore, and the Assam valley, and the evidence, so far as it is at present available, points to the insect having only a cold season activity in the greater part of India.

The pest has been officially reported in only one instance when it was sent in as being destructive in a garden in Dumraon. The destruction caused to field crops in Pusa has been negligible in each season.

In Surat, it is destructive to the cabbages grown by market gardeners for sale in the bazar, since the cabbages are unsightly and cannot so readily be sold. The cultivator there has a habit of collecting the larvæ in an earthen pot, but he is averse to destroying them, and, removing them to a little distance, he liberates them.

In Nagpur, the Entomological Assistant reports the insect as destructive to cabbage, radish and turnip grown as vegetable crops in gardens. This appears to be the only way in which it is a real pest, and experiments in Surat have shown that hand-picking into a vessel of water with a film of kerosene over is the simplest treatment, within the reach of a cultivator, but that spraying the plants with weak kerosene emulsion was the best treatment where it was possible.

In Pusa, plants were easily protected by dusting on a mixture of lime (20 pints) and kerosene (1 pint), which renders the plant distasteful. It has also been found that a trap crop of early mustard, sown so as to be well up when the main crop is being sown, is an excellent check, since the emerging adults lay their eggs in these plants ; the trap crop with its eggs and larvæ is removed when the main crop comes up. Should it be found that this insect is a serious pest, as is likely in some localities, we believe that such a crop will be the simplest check.

Habits —The habits of this insect in the insectary are dealt with below. In the field, the adults can be seen flying by day or sitting on the plants. The winged insect flies slowly and is sluggish by day ; it is more active at dusk and comes out then. Males and females occur in about equal numbers and the parthenogenesis, common in members of this family, does not occur in this species. The larvæ are semi-nocturnal, being active in the early morning and the evening ; in the middle of the day they hide in the soil or under shelter and come up before sunset. The leaves are eaten from the edge inwards and the larva displays none of the voracity common to Lepidopterous larvæ.

The full-grown larva makes two kinds of cocoons ; in some cases, it pupates between two leaves in a thin cocoon of white

silk ; this apparently takes place on the young crop or when a dormant larval period is not going to be entered upon. In other cases and always before æstivation, the cocoon is formed in the soil and is far more dense, with an outer covering of agglutinated soil.

Life History.—The life history of *Athalia proxima* in the insectary is passed partly on the food-plants, *viz.*, radish, mustard and other cruciferous plants and partly in the soil. Eggs are laid inside the tissue of the leaves. The grubs which hatch out of them, feed on the leaves until they are full-grown, when they leave the plants and enter the soil. There they form cocoons in which pupation takes place. After varying periods the sawflies come out and again lay eggs. The cycle is thus completed.

Athalia proxima has got only a winter season activity. It may have one or two or at the most three generations during the cold weather, and passes the rest of the year as a larva in the pupal cocoon under-ground in a resting condition ; in some cases the resting larva may pass over one whole winter and may not attain the adult stage till the second year, there being, therefore, no generation during the whole year. It turns into the pupa shortly before it emerges as an imago. Its activity, however, may not continue throughout the winter and it may enter upon the long rest in the middle of winter when it is yet very cold. Also it may commence active life after the long period of rest when the signs of approaching winter are hardly perceptible. Again, sawflies have been seen to emerge when summer weather has set in and after general resting has begun. But such cases are so solitary, that a fresh brood in warm temperature or summer is rarely possible. These points will be evident from an examination of the dates given below.

(1). Many grubs were collected on the 9th December 1905. These formed pupal cocoons by the 4th January 1906.

(2). More grubs were collected on 10th January 1906. These formed pupal cocoons by the 25th January 1906.

(3). Some grubs hatched from eggs between the 28th December 1905 and 7th January 1906. These formed pupal cocoons by 10th February 1906.

Out of them

One emerged as sawfly—4th March 1906.

Another ,, ,, 5th ,, ,,

A third ,, ,, 26th ,, ,,

The rest of the lot (3) and all of lots (1) and (2) continued to rest in the pupal cocoons in the larval state.

The first of them emerged as a sawfly on 29th September 1906.

76 emerged as sawflies between 9th October and 1st November 1906.

1 emerged as a sawfly on 9th March 1907.

2 ,, sawflies on 2nd November 1907.

Again.

(4). A lot of grubs, hatched from eggs, formed pupal cocoons by 10th December 1906. Of these only 1 emerged as a sawfly—2nd January 1907.

(5). Another lot formed pupal cocoons by 19th December 1906.

Of these 1 emerged as a sawfly—11th January 1907.

1 ,, ,, 15th ,, ,,

1 ,, ,, 16th ,, ,,

1 ,, ,, 26th ,, ,,

The rest of both the lots (4) and (5) continued their rest. No more sawflies emerged in the Insectary. But on the 27th March two larvæ were collected from a stray mustard plant. One died. The other formed the pupal cell on the date of collection and emerged as imago on the 12th April. The sawfly died on the 17th April, although it was well taken care of to see whether it could live through the summer.

The winter of 1905-06 was a very cold one. In such a year *Athalia proxima* may remain active from October till January. In a winter, however, which is not very cold (like that of 1906-07),

it may commence the long rest in December. Generally the grubs begin to rest in January and come out as sawflies in October, after a period of about 9 or 10 months.

One grub is seen to have formed the pupal cocoon in January 1906 ; it passed the winter of 1906-07 in the resting condition in the cocoon, and came out as an imago on the 9th March 1907, after a long resting period of about 14 months. It came out at a time when summer temperature was setting in and general resting was long ago begun. It is most probable that it passed over the winter of 1906-07 because it was not sufficiently cold ; but it came out as the adult fly later on in March, because it found the laboratory conditions not in favour of its continuing in the larval state till the following September or October. Also two grubs are seen to have formed the pupal cell about January 1906, and come out as imagines on 2nd November 1907 ; thus a grub may prolong its period of rest to about 21 or 22 months, and may include one whole winter in it, although winter is the time of its activity.

Athalia proxima has got no definite broods, adult flies as well as grubs in all stages being found at the same time. The reason of this is that the imagines do not come out at the same time after the long period of rest. The 76 flies which emerged between 9th October and 1st November 1906, came out in the following manner :—

Date of emergence.	October 9th.	October 10th.	October 11th.	October 12th.	October 14th.	October 15th.	October 16th.	October 18th.	October 19th.	October 20th.	October 21st.	October 22nd.	October 23rd.	October 24th.	October 25th.	October 26th.	October 29th.	October 30th.	October 31st.	November 1st.	Total.
Number of flies ...	7	5	4	2	2	3	5	3	1	2	8	4	6	9	6	2	2	3	1	1	76

The life cycle is illustrated in the table below. There is no regularity in its periods which vary a great deal for members born at the same time. Some may rest ; while others hatched from eggs laid at the same time by the same fly may pass through one or even three generations. On a comparison of the table given below and the dates given above,

it will be evident that *Athalia proxima* can only have one or in some cases two or, at the most, three generations during the year. The shortest period of the cycle is about four weeks ; the longest period noticed is about 21 or 22 months. In the table the dates, when the pupal cocoons were formed, are noticed. As will be seen later on, the grubs turn into pupæ shortly before they emerge as flies ; the actual pupal stage is very short, occupying only about five or six days.

Eggs laid.	Eggs hatched.	Grubs formed pupal cocoons.	Sawflies emerged.	Duration in days.
10 X	14 X	27 X	9 XI	30
11 X	15 X	27 X	8 XI	28
14 X	18 X	29 X	9 XI	26
15 X	19 X	30 X	11 XI	27
17 X	21 X	4 XI	18 XI	32
15 XI	21 XI	10 XII	2 I	48
21 XI	28 XI	17 XII	11 I	51
26 XII	2 I	5 II	4 III	68
27 XII	4 I	10 II	Middle of October	About 9½ months.
31 XII	7 I	10 II	26 III	85
.....	.....	January 1906	9 III 07	About 15 months.
.....	.....	January 1906	2 XI 07	About 22 months.

Eggs.—Oviposition takes place only during the day time, from morning till some time before sunset. Eggs are laid inside the tissue of the margins of leaves. The female fly possesses a small black saw-like apparatus at the lower side of the abdominal end ; hence the name "sawfly." The margin of the leaf is slit open by means of this apparatus and the egg deposited inside. The female will be found sitting almost motionless on the margin of the leaf for less than a minute during which the saw works and the egg is thrust in. Many eggs may be laid in the same leaf, but only one at each place. The eggs are not visible, and there is no sign to show that they have been laid on any plant. Some sign appears later on as the time of hatching approaches. About a day before the grubs hatch out of the leaf tissue, small bulgings of the surface of the leaf are seen along its margin, the bulgings indicating where the eggs have been deposited. They are caused by the activity of the hatching young grubs.

Of the 76 sawflies which emerged between the 9th October and 1st November 1906, about 60 were given full opportunity of

coupling and laying eggs. The eggs could not be counted as they were hidden within the tissue of the leaf; but from them 902 grubs hatched out in all. If 30 of the above 60 sawflies are taken to be females, it is seen that each female lays about 30 eggs on the average.

The egg stage varies from about four to about seven or eight days according to the coldness of the time. The gradual lengthening of the period is shown below :—

Eggs laid.	Eggs hatched.	Duration in days.
10 X	14 X	4
15 X	19 X	4
23 X	28 X	5
4 XI	9 XI	5
15 XI	21 XI	6
21 XI	28 XI	7

Larva.—The young larva is a little less than 2 mm. long and cylindrical in shape. The head is black, round and flat in front; its axis is nearly at right angles to the body axis. The body shows no sign of segmentation and is minutely wrinkled transversely; it is hairless and so soft that it is liable to be pierced by the prickly hairs on radish and mustard leaves; when thus pierced a drop of a clear watery liquid exudes and collects at the place; the grub however does not mind these pricks. The colour is greenish grey. The thorax is thicker than the rest of the body. There are three pairs of thoracic legs and eight pairs of prolegs.

The larva turns darker as it grows; ultimately it becomes sooty black. After the 2nd moult a black stripe appears on each side of the dorsum. After the third moult one black stripe appears in the median line, and one more faint black stripe laterally near the base of the legs. The median stripe runs from the meso-thorax and not from near the head. As the surface of the body is minutely wrinkled, the stripes seem to be made up of a number of small points placed in rows; they become more and more prominent in succeeding instars. The full-grown larva measures about 16-17 mm. It does not differ materially from the young grub, but only undergoes the above changes.

Generally the larva moults six times before it pupates. Only one out of six larvæ, which were watched, passed through one more moult. Before each moult the larva rests for a few hours. The moult of the head is not cast separately like most caterpillars. In all the moults, the upper side of the head and of a part of the thoracic skin bursts longitudinally and the skin is cast off in not more than five minutes' time. Just after a moult the head is creamy white and shows a grey spot on each side, the body also looks greenish grey and not so dark as later on in the instar. Below are shown the number of moults and the length of the instars. The period of the last instar varies from about five days in the active season to generally about nine or ten months; in one case it was observed to extend to about 14 months and in two other cases to about 21 or 22 months. Some of the dates, given in the table, for the last moult at which the grub turns into the chrysalis are guessed, because they could not be observed in every case, as the moult was cast after varying periods.

Hatched.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.	6th moult.	7th moult.
Length about 2 m.m.	3 m.m.	5 m.m.	7 m.m.	10 m.m.	13 m.m.	16 m.m.	...
14 X	17 X	19 X	21 X	23 X	25 X	2 XI	...
15 X	18 X	20 X	22 X	24 X	26 X	1 XI	..
18 X	20 X	22 X	23 X	25 X	27 X	3 XI	...
19 X	22 X	24 X	25 X	27 X	29 X	4 XI	...
21 X	25 X	27 X	29 X	31 X	3 XI	10 XI	..
4 I	13 I	20 I	26 I	30 I	2 II	7 II	October.

As has been said above, the eggs are laid inside the tissue of the leaf. The young larvæ eat their way out and go on feeding on the leaves, producing in the beginning small holes in them. The grubs are slow-moving insects. As many eggs may be laid on the same plant, frequently many larvæ are seen to remain congregated on the same plant or on plants close to each other. If the plants are shaken, the grubs coil up and fall to the ground; they, however, climb up again after some time. They are not in the habit of injuring one another.

The larval stage of *Athalia proxima* may be very properly divided into two periods, *viz.*, (1) the active larval period which

lasts as long as the grub is active and eats food; and (2) the resting larval period when it rests in the pupal cocoon. The active larval period may vary from about 11 to about 37 days according to the coldness of the time. It is shown below :—

Eggs hatched.	Grubs formed pupal cell.	Duration in days.
14 X	27 X	13
19 X	30 X	11
21 XI	10 XII	19
28 XI	19 XII	21
4 I	10 II	37

The question of the resting larval period has been discussed in the beginning. In the active season it is about five days; one larva formed the pupal cell and began to rest on the 30th October, and it actually turned into the pupa on the 4th November.

Pupa.— When the grubs are full-grown and full-fed they leave the plants and enter the soil. There they form elongated oval seed-like cocoons or pupal cells and rest within them before pupation. The cocoon or the pupal cell is made of a very closely and thickly woven silken stuff secreted from the mouth. Earth seems to enter into its composition on the outside; externally it is earth-coloured: also the adhering earth cannot be completely washed off. Internally the colour is brown and glossy. The cocoon affords a good protection to the resting larva; it is perfectly water-proof; water cannot make its way into it even when it is kept submerged for a long time; also it is scarcely damaged unless squeezed between two tolerably hard bodies. As noticed above, many grubs may remain congregated on the same plant or on plants close to one another. Naturally when they enter the soil to build the pupal cocoons, many cocoons come to be formed at the same place. It is probably for this reason that frequently cocoons are found in a lump.

As described above, the larvæ do not turn into pupæ just after securing themselves in the pupal cells, but rest for widely varying periods. The actual pupal period is very short, being

about only five or six days. What was observed in the case of three grubs is given below :—

Building of the cocoon and commencement of rest.	Last larval moult and formation of pupa.	Emergence of the imago.
30 X	4 XI	10 XI
.....	13 XI	18 XI
January 1906.	5th March 1907.	9th March 1907.

The pupa is about 7 m.m. long. The antennæ, legs and the wings are folded on the ventrum. The colour of body, when the last larval moult is cast, is white with a greenish tinge and a black mid-dorsal line ; the eyes are blackish ; the appendages of the head, the legs and the wings are all white. Gradually the head becomes black, and then the thorax with the wings and legs ; the abdomen becomes yellow.

Imago.—The pupa casts off only a very thin, somewhat transparent pellicle and attains the adult stage. The adult sawfly does not or cannot emerge from the cocoon at once ; it bites a big hole at one extremity and comes out through it. It measures about 8 to 10 m.m. from the head to the end of the wings. Its antennæ, head, wings, tibiæ and tarsi are black, the rest of the body and its appendages being yellow.

The adult flies do not generally fly to a great distance ; but are seen to flit about from leaf to leaf or plant to plant. They are active only during the day time. With the setting of the sun their activity ceases, and they pass the night sitting motionless anywhere on the plants or on the ground, and hardly stir even when light is introduced. The females are a little bigger than the males. They couple end to end, and may pair and lay eggs on the day of emergence. In the Insectary they lived from two to six days.

Parasites.—The larvæ of *Athalia proxima* are liable to be parasitised by two species of Ichneumon flies. The peculiarity in the life of the parasites is that they also rest with the host for the greater part of the year, and it seems that they have got only one generation during the year. Some sawfly larvæ were

collected from the fields on 9th December 1905. Some more larvæ were collected on the 10th January 1906. A few of the larvæ were parasitised before these dates of collection. All of the above two lots formed pupal cells and began to rest by the 25th January 1906. Most of those which were not parasitised, came out as sawflies between the 29th September and 1st November 1906. Some parasites came out between 12th November and 8th December. Thus the complete cycle of the parasites took about a year. They come out some time after the sawflies, so that they may be sure of finding the sawfly larvæ in the fields. From their behaviour it appears that they claim only *Athalia proxima* as their host.

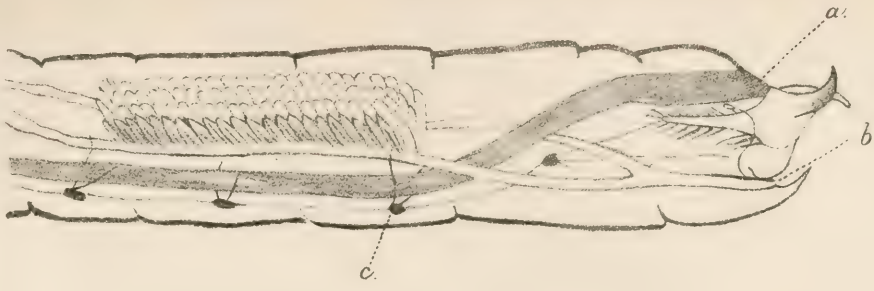
Explanation of Plate XX.

(1) Just hatched larva × 6 (Lateral aspect).
(2) Larva in the 3rd stage × 6. (Do.)
(3) Full-grown larva × 6. (Do.)
(4) Full-grown larva on the leaf × 3 (Dorsal view).
(5) Dorsal aspect of pupa (in the advanced stage) × 6.
(6) Ventral aspect of pupa (newly formed) × 6.
(7) The sawfly (the imago) × 6.
(8) A cluster of cocoons, the adhering earth being removed to some extent (each enlarged 4 times). One of the cocoons shows the mode of emergence of the imago.
(9) A single cocoon from which the adhering earth has been washed off × 4.
(10) A parasite × 4.

PLATE I.

Acridium Succinctum L.

PLATE II.
Area infested in
1903-1904.



1.

2.

3.

4.

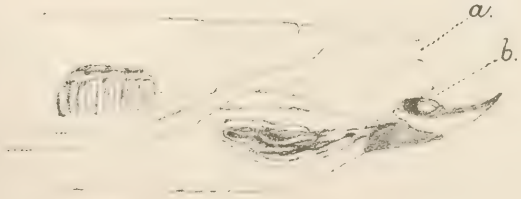
5.

6.

7.

8.

9.



10.

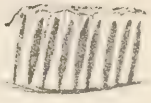


PLATE IV.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

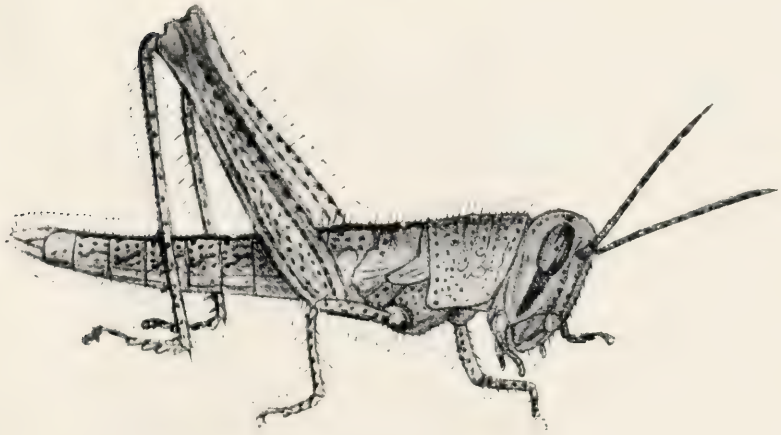


FIG. 7.

PLATE V.

Fig. 1.

Fig. 2.

Fig. 3.

PLATE VI.

FIG. 1.

FIG. 2.

FIG. 3.

PLATE VII.

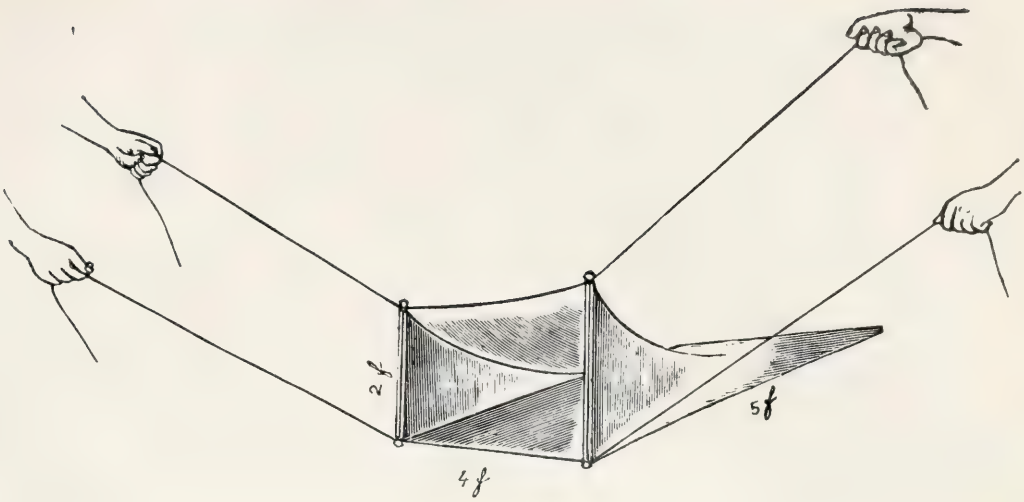


FIG. 1.

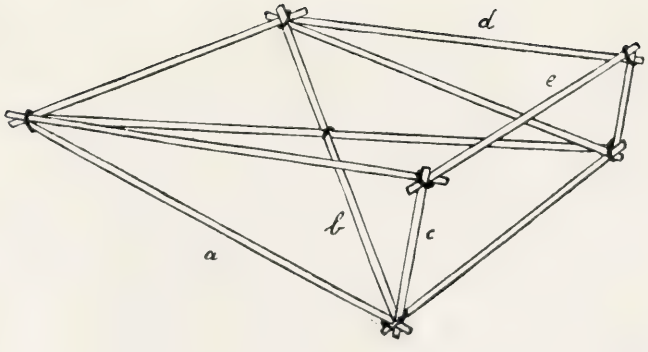


FIG. 2.

Fig. 1. Acridium succinctum, Linn.

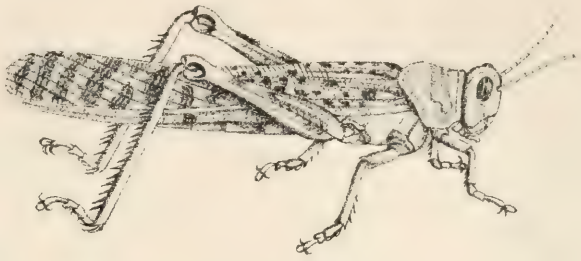


Fig. 2. Acridium peregrinum, Oliv.

Fig. 3. Acridium aeruginosum, Burm.

Fig. 4. Hieroglyphus furcifer, Serv.

Fig. 4. Locust in Cylinder.

Fig. 1. Acridium succinctum, Linn.

Fig. 2. Acridium peregrinum, Oliv.

Fig. 3. Acridium aeruginosum, Sauss.

H. Hormusji del. A. C. Chowdhary lith.

DORSAL VIEW OF THORAX.

Fig. 1. ♀.

Fig. 2. ♂.

Acridium succinctum, Linn.

Fig. 3. ♀.

Fig. 4. ♂.

Acridium peregrinum, Oliv.

Fig. 5. ♀.

Fig. 6. ♂.

Acridium aeruginosum, Burm.

Fig. 7. ♀.

Fig. 8. ♂.

Hieroglyphus furcifer, Serv.

PLATE XI.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

PLATE XII.

Fig. 1.

Fig. 2.

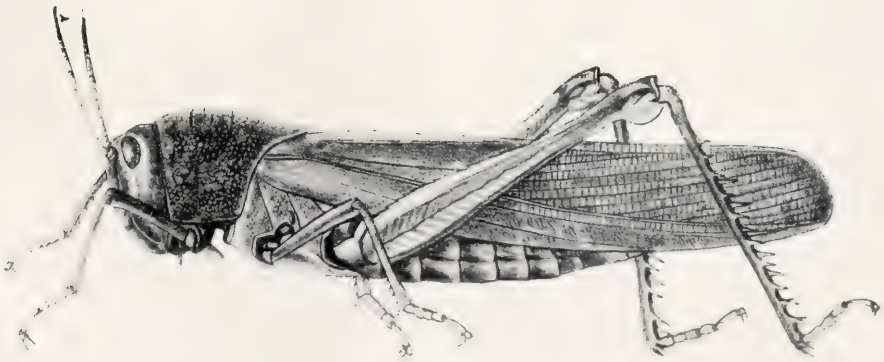


Fig. 3.

PLATE XIII.

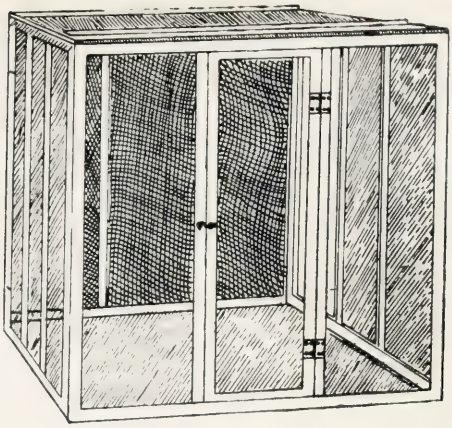


FIG. 1.

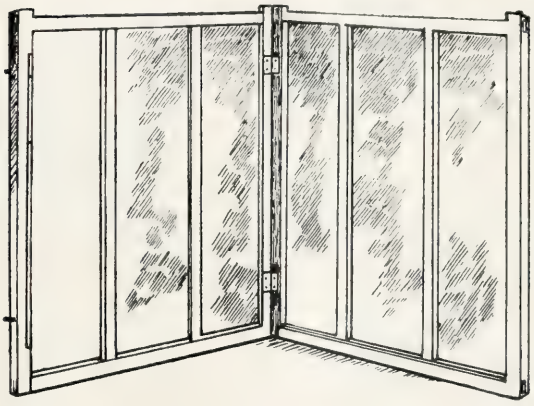


FIG. 2.

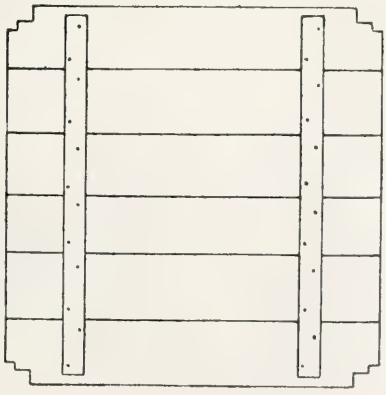
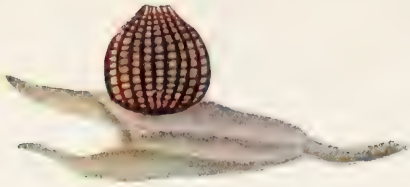
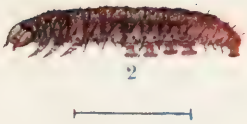


FIG. 3

PLATE XIV.



1



2

3

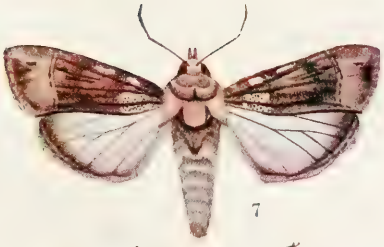
4

5

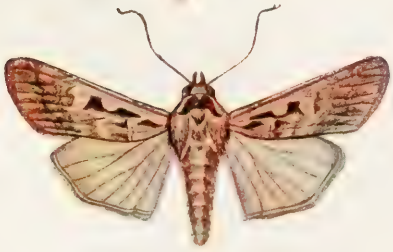
6

8

10



7



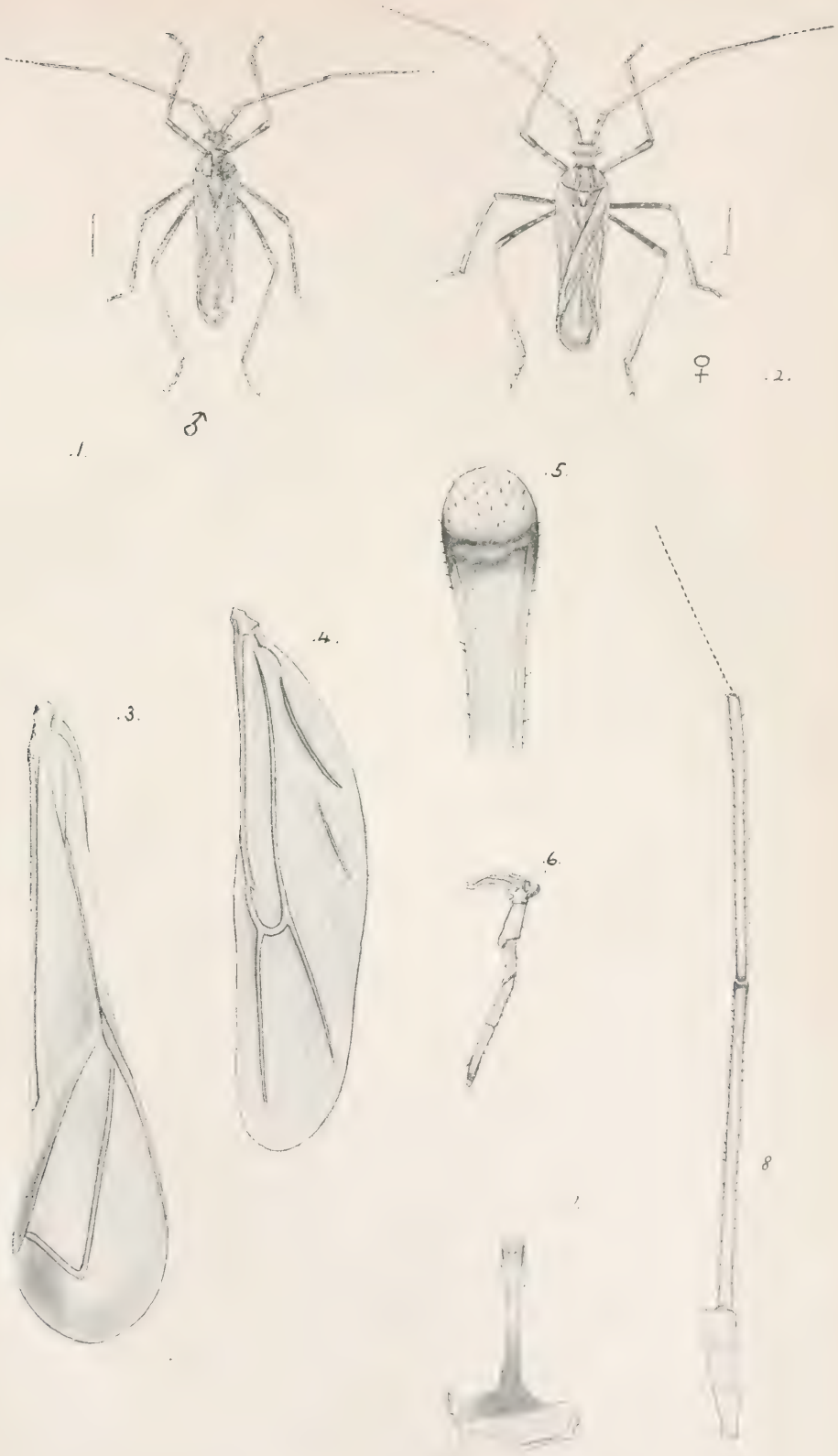
9

11

THE INDIAN SURFACE CATERPILLARS.

Engraved and Printed
at the Calcutta Phototype Co.

PLATE XV.



HELOPELTIS CINCHONÆ *n. Sp.*

PLATE XVI.

Fig. 2.

Fig. 1.

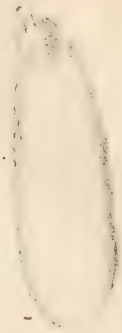


Fig. 3.

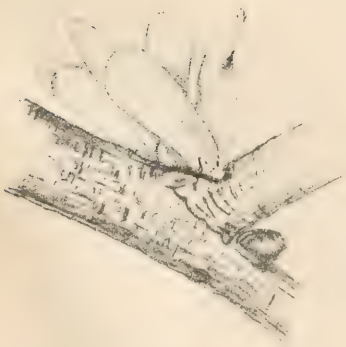


Fig. 4.

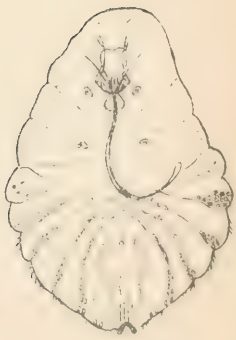


Fig. 5.

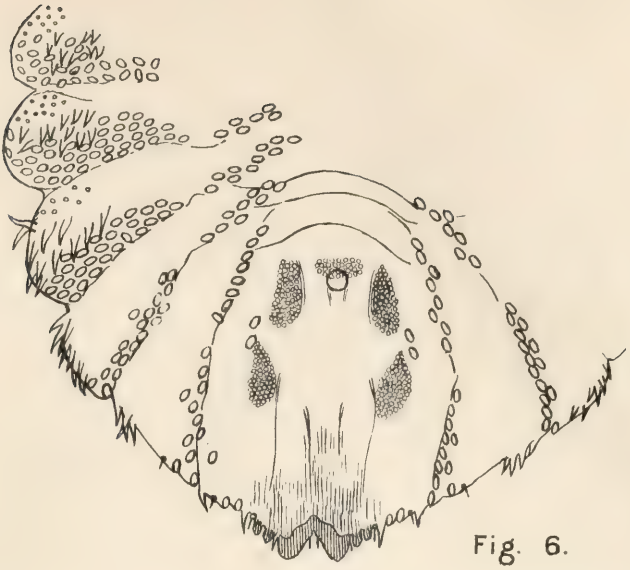


Fig. 6.

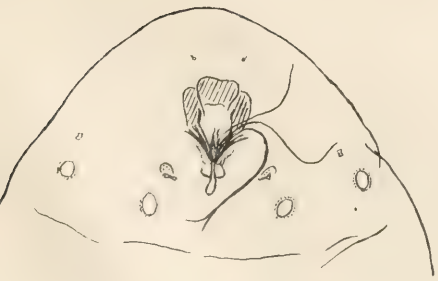


Fig. 7.

Fig. 8.

Fig. 9.

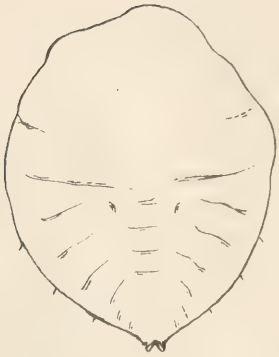


Fig. 10.

Fig 11.

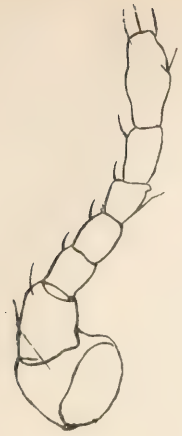


Fig. 12.

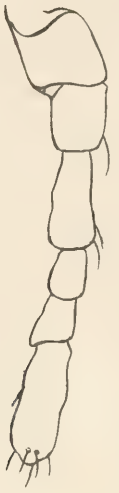


Fig. 13.

Fig 14.

Fig. 15.

Fig. 16.

Fig. 17.

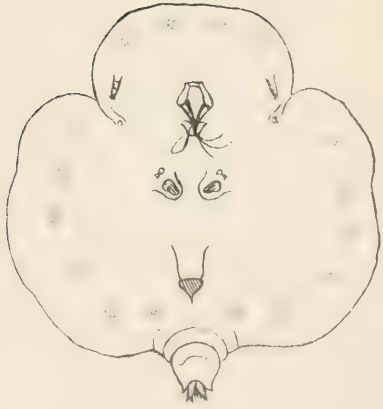


Fig. 18.

PLATE XX.

MUSTARD SAWFLY.

Engraved and Printed at The Columbia Typo

P
Agric
I
119627
Imperial Agricultural Research Institute,
Delhi
Memoirs... Entomological Series.

University of Toronto
Library
Medical
Serials

DO NOT
REMOVE
THE
CARD
FROM
THIS
POCKET

STORAGE

Acme Library Card Pocket
LOWE-MARTIN CO. LIMITED